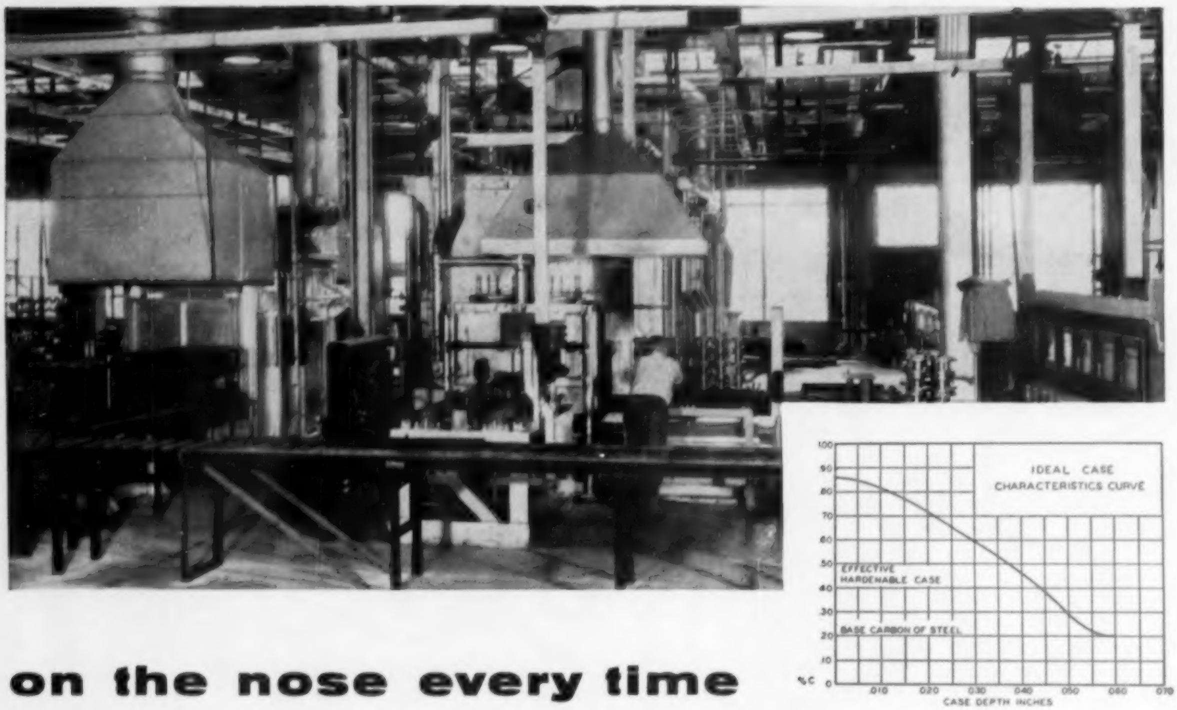
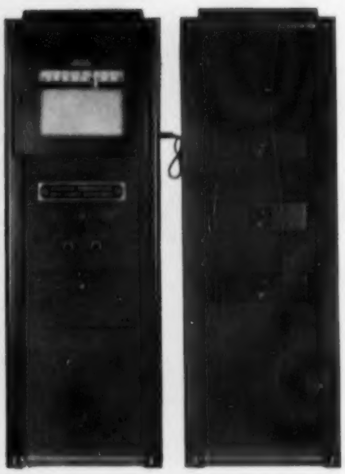

Metal Progress



on the nose every time

WITH SURFACE AUTOCARB AUTOMATIC CARBON POTENTIAL CONTROL



New high physicals in carburized gears—better tooth-to-tooth and gear-to-gear uniformity—faster cycles—automatic compensation for changes in work surface area during furnace operation . . .

These are the chief benefits Warner Gear Division, Muncie, Ind., achieves in its most recent continuous gas carburizing line, using the 'Surface' fully automatic carbon potential control system. In a nutshell: The Surface dewpoint recorder-controller periodically checks carbon potential in each of three zones in the furnace (with a range of .3 to 1.1% carbon), controls mixing valves to deliver correct additions of air or gas to maintain desired carbon potential in each zone. This system eliminates the human element in controlling carbon potential. It also provides Warner Gear with the necessary close control required for the practical carburizing of gears with near-eutectoid surface carbon concentrations.

Write for Literature H-54-2.

Surface

HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION • TOLEDO 1, OHIO

ALSO MAKERS OF

Kathabar HUMIDITY CONDITIONING *Janitrol* AUTOMATIC SPACE HEATING

Metal Progress

Volume 68, No. 1

July . . 1955

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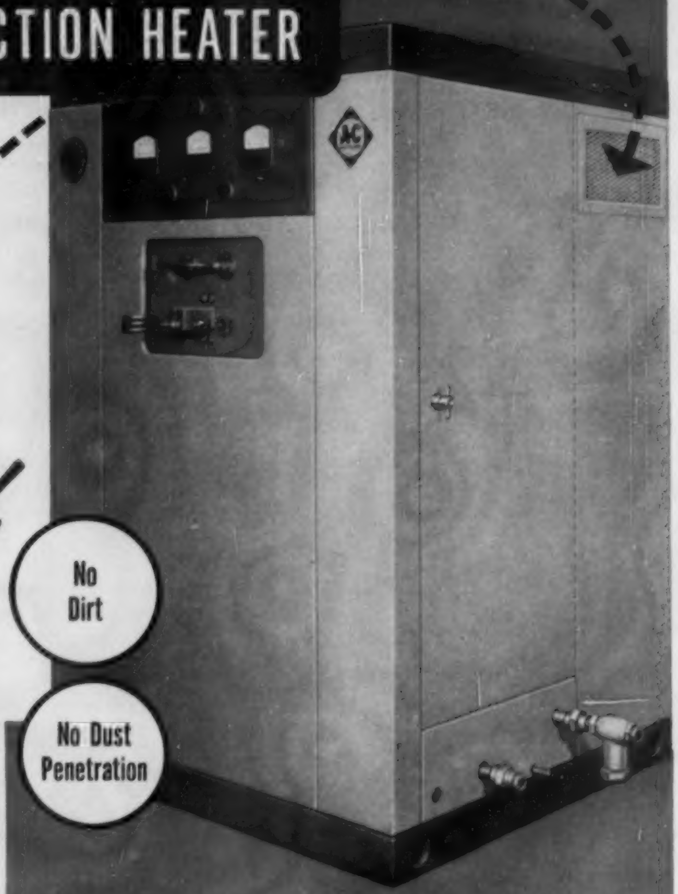
**The coding symbols refer to the ASM-SLA Metallurgical Literature Classification.*

Metal Progress

Contents Continued

25 KW INDUCTION HEATER

IT'S NEW ...IT'S *Air-Conditioned*



Allis-Chalmers 25-kw unit is designed and constructed to handle heavy-duty industrial processing applications.

In the new Allis-Chalmers 25-kw induction heater, filtered air keeps pressurized cabinet clean and dry. Contamination of mechanical and electrical parts is prevented; maintenance and cleaning are greatly reduced.

How It Works

Air taken in through filter to cool components maintains an internal pressure higher than atmospheric pressure. Outward seepage prevents entry of dust-laden air.

Another important feature is the *built-in cooling system* which circulates temperature-controlled distilled or mineral-free water. Because cooling function is independent of raw water system fluctuations, cooling system maintains constant pressure and continuous cooling. Sweating is eliminated, even in humid weather. A-4789

If your operation involves brazing, soldering, annealing, or hardening, profit in the advantages of Allis-Chalmers induction heating —

- Fast Heating
- Low Heat Loss
- High Production
- Minimum of Rejects
- Positive Control
- Low Maintenance
- High Quality Product
- Easy Cleaning

For complete information on units to fit any application requirement, contact your A-C district office or write Allis-Chalmers, Milwaukee 1, Wisconsin. Ask for induction heating information packet.

A-C ALLIS-CHALMERS

ALLIS-CHALMERS

As I was saying...

His Royal Highness, the Duke of Edinburgh, was patron of the Joint Metallurgical Societies Meeting while we were in the United Kingdom. Sir Charles Bruce-Gardner, president of the Iron and Steel Institute of Great Britain, was chairman of the opening plenary session held in Assembly Hall, Church House, Westminster, London, on Wednesday, June 1, 1955. At this meeting the chairman made the announcement that by action of the Council of the Institute an honorary membership in the Iron & Steel Institute had been voted to William H. Eisenman, secretary of the American Society for Metals. (When this honorary membership was conferred, there were only six living honorary members, only one American. In the 90-year history of the Iron and Steel Institute, only 49 honorary memberships have been granted.)

I arose and said: "Mr. President of the Iron and Steel Institute, Members of the Council, Ladies and Gentlemen—Today and at this hour, as I receive and accept this very distinguished honor, I am having formed for me one of the highlights of my exciting and interesting career as secretary of the A.S.M., which began some 37 years ago. Another memorable occasion, and one of my first duties as secretary, was to notify a former president of your Institute, your late honored and revered member, Sir Robert Hadfield, that he had been unanimously selected as the first honorary member of the new American Society for Steel Treating, now known as the American Society for Metals.

"I recall again most vividly the very courteous reception I received at Sir Robert's hands during my first visit to England in 1926, when we looked into the future and visioned that some day a meeting of such a nature as this meeting now in progress could take place between the metallurgical societies. This meeting has required a longer time than we contemplated, but it is a supreme satisfaction to me to witness its fulfillment.

"There are two very important and significant interpretations in this great honor you have bestowed upon me: (1) It is a recognition of the world-encircling achievements of the youngest metallurgical society; (2) it is a recognition of the work done by each one of the 24,000 members of the American Society for Metals who have contributed so much through the Society to the advancement of metals.

"As the humble representative of the entire membership of the American Society for Metals I accept for them this honorary membership in the Iron and Steel Institute with the most grateful and sincere thanks of all of us."

And so I have accepted this great honor for you. It was a proud moment for you, and especially for your secretary.

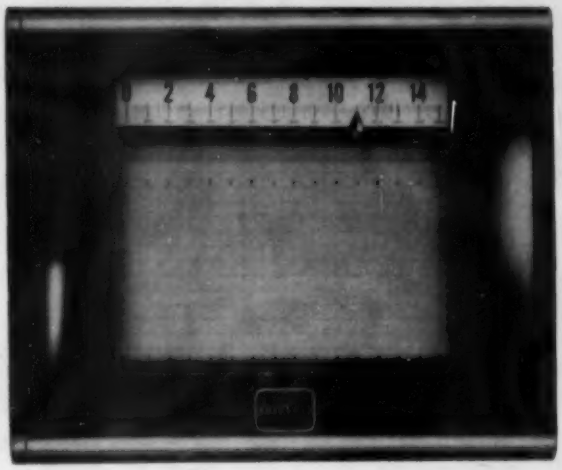
Cordially yours,

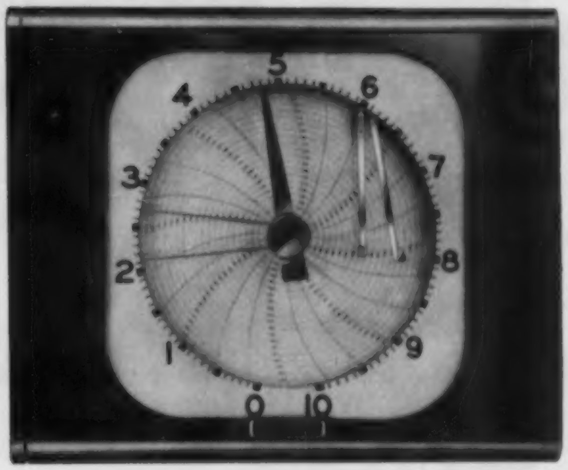
W. H. Eisenman, *Secretary*
American Society for Metals

Bill

WHAT'S NEW AT BRISTOL...

Three Ways to Better Temperature Control





BRISTOL ELECTRONIC DYNAMASTER® POTENTIOMETERS

CONTINUOUS STANDARDIZATION WITH NO DRY CELLS: Bristol Dynamaster Potentiometers with No-Batt Continuous Standardization which eliminates need for dry cells. Results: no interruption in operation for standardization, no batteries to replace.

A MODEL FOR EVERY REQUIREMENT: Dynamaster Potentiometers are available as single-pen, two-pen, and multiple-record (up to 24 points) *strip-chart* instruments and as *round-chart* instruments.

ELECTRIC AND PNEUMATIC CONTROLLERS. Both strip- and round-chart instruments are made in a very wide variety of controllers that meet every furnace and oven control requirement, including the following in a great many forms:

Electric Control — on-off, average position, proportional input, 3-position, proportioning, proportional with automatic reset, and time-program.

Pneumatic Control — on-off, proportional, and proportional with reset.

FREE-VANE® ELECTRONIC PYROMETER CONTROLLERS

- **Very minute changes in temperature** at the control point (less than 0.003" on scale) closes or opens the Thyratron-operated relay with positive trigger action.
- **New high-torque, rugged millivoltmeter measuring mechanism** gives greater accuracy — Alnico V magnet — and a sensitivity of 15 ohms per millivolt.
- **Separate control units are plug-in.**
- **Wide variety of models** — available in thermocouple and radiation pyrometer controllers in ranges up to 4000°F for L, H, LH, LOH, and LNH control and for L and H with proportional input control.

FOR MORE FACTS about these three rugged Bristol Furnace and Oven Controls write for free Bulletin P1260 today. It's a 48-page booklet of useful data, specifications, control diagrams and prices for every type of automatic heating control. The Bristol Company, 106 Bristol Road, Waterbury, Conn. 5.5

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

...in the use of ZINC DIE CASTINGS

A prime factor in the rapidly growing use of die castings has been the recognition of the process for what it has proved itself to be: The shortest distance between raw material and finished part. The automotive industry has been especially alert in taking advantage of this high speed production tool. 1955 models use eight times as much zinc die casting in front-end assemblies as the '54 models did.

Since this industry has been the top user of zinc die castings right along — taking more than half the total last year — the impressive swing to more zinc is significant. It definitely establishes the fact that zinc die castings are less costly to produce than those based on any other metal. Because of its low melting point, zinc can readily be cast in the most highly automatic machines. The more automatic and the more rapid the casting cycle, the greater the savings on costs. The smooth, as cast surface of zinc alloy castings is practically ready for plating. This gives zinc an advantage over all other die casting alloys for use as decorative objects and trim. In addition to all of the eye-catching chromium plated zinc die castings, the functional out-of-sight carburetor, fuel pump and windshield wiper housings continue to be zinc die cast at lowest cost.

The utilization of zinc die castings is also making rapid advances for important components in home appliances, hand tools, instruments, electrical equipment, business machines and innumerable other products which, were it not for zinc die castings, would be neither as attractive in appearance, as rugged, nor as low in cost.

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SALES OFFICE FOR PACIFIC COAST **NORTHWEST LEAD COMPANY** SEATTLE, WASHINGTON


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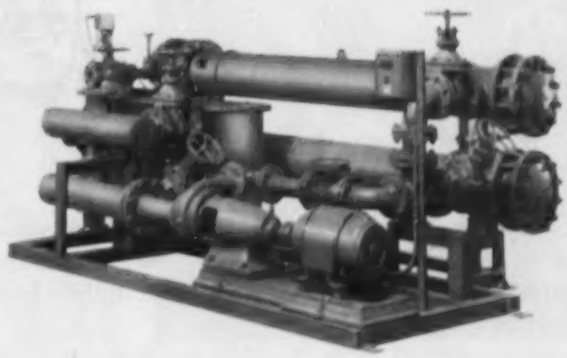

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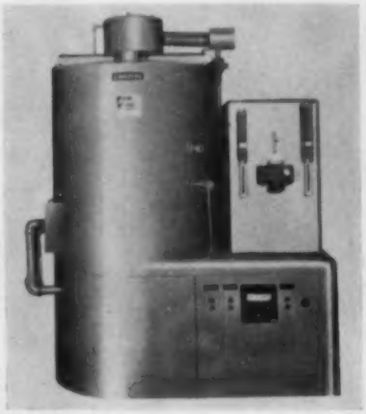
INDUSTRY'S WORKSHOP FOR THE FINEST IN PLATING AND POLISHING PROCESSES • EQUIPMENT • SUPPLIES

Engineering Digest of New Products . . .

Gas Generator

A new fully automatic endothermic atmosphere generator for producing protective atmospheres for bright hardening, bright annealing, or bright brazing of steel has been announced by Lindberg Engineering Co. It is



available at 500, 750, and 1500 c.f.h. The atmosphere composition when cracking natural gas will be approximately 20% carbon monoxide, 40% hydrogen, 1% methane and balance nitrogen. Dewpoint is 10°F. At the leanest setting the atmosphere composition will be approximately 4.5% carbon dioxide, 10% carbon monoxide, 20% hydrogen, and balance nitrogen. Dewpoint in this case is 60°F. By changing the air-gas ratio, the analysis of the gas produced can be varied and thus readily changed so as to be in equilibrium with steels of different carbon content.

For further information circle No. 1 on literature request card, p. 32-B.

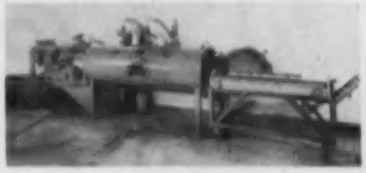
Chromium Plating

A new production plating process that deposits a corrosion resistant chromium plate on steel has been announced by United Chromium, Inc. It can be plated directly on steel, without the necessity for an undercoat of nickel or copper and nickel. The deposit has light gray matte appearance which can be buffed to a high luster. Unichrome crack-free chromium plating is done with a special chromic acid-type bath having automatic regulation of the catalyst concentration. Standard plating equipment and procedures are used. The bath is prepared by dissolving the proper amount of Unichrome SRHS Compound CF-500 in water. Its plating speed is about the same as that of ordinary chromium plating.

For further information circle No. 2 on literature request card, p. 32-B.

Vacuum Welder

Vacuum Specialties, Inc., has announced a combination arc welder and ingot surface conditioner. As a welder, the unit joins cylindrical sections of reactive metals under closely controlled conditions. The carriage is positioned by an hydraulic operator so that a seam is located directly under an electrode. The electrode is lowered into welding position, and the welding current started. When the seam has been automatically welded, the carriage is moved to properly locate the subsequent seams. As a surface conditioner, the carriage

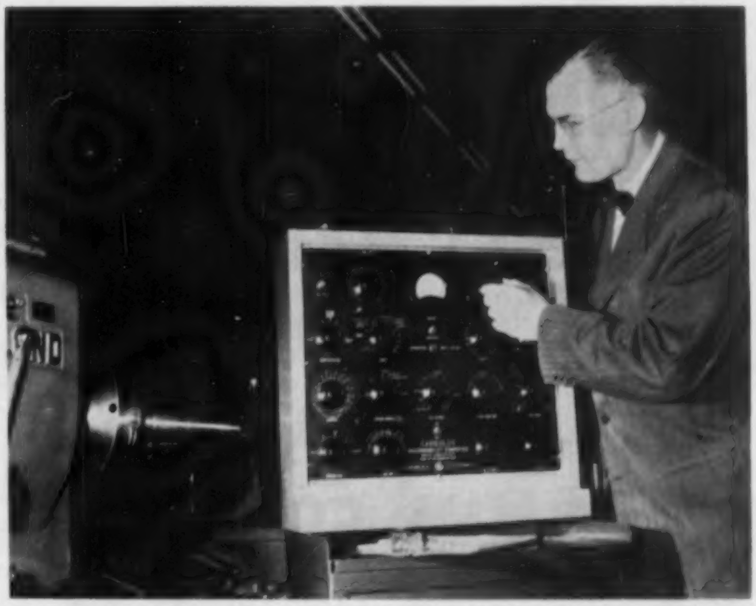


is moved continuously along the axis of the tank by a lathe-type drive and the surface is progressively melted in a helical path by one or more electric arcs. Surface imperfections more than % in. deep are eliminated. The tank is evacuated to

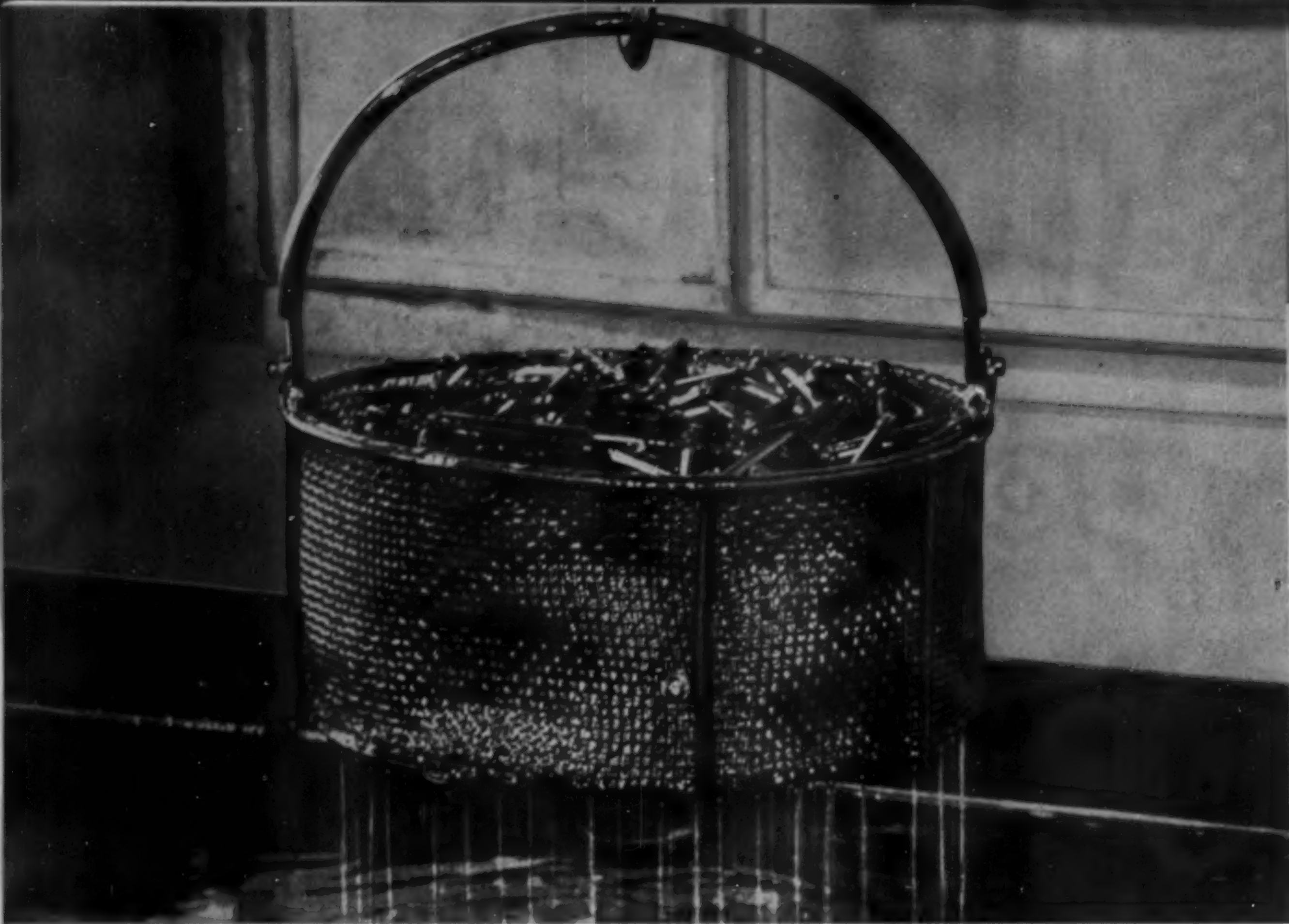
Machinability

A new electronic machinability computer has been announced by the Carboloy Dept. of General Electric Co. It will solve in less than 2 min. machining problems which normally take several hours to compute. The 32-lb. self-powered analog unit measures 21 x 7 x 20 in., and will consider fourteen operational variables in machining, such as grade of carbide, speed, feed, depth of cut, tool life, alloy and material hardness. Answers provided by the computer are based on the use of those feeds, depths of cut, proper grades of carbide and tool geometry which will result in a normal, wear-type, cutting edge failure.

For further information circle No. 3 on literature request card, p. 32-B.



Dr. W. W. Gilbert at the Machinability Computer He Developed



You Get Minimum Drag-out with Sun Quenching Oil Light

When you reduce oil consumption by lowering drag-out, you cut a major cost in operating a quenching system. Sun Quenching Oil Light thins out when heated, drains off parts faster and more completely. And Sun Quenching Oil Light, because of its natural detergency, prevents the formation of sludge deposits, aids in removing any deposits that have accumulated. And under normal operating conditions it need never be replaced. Sun's booklet "Sun Quenching Oils" tells about this low-cost oil. For a copy, call your nearest Sun office or write SUN OIL COMPANY, Philadelphia 3, Pa., Dept. MP-7.

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less than 50 microns pressure with the carriage and work load in place. The protective atmosphere is introduced and the work load is rotated by the drive rollers on which it rests.
For further information circle No. 4 on literature request card, p. 32-B.

Billet Heater

Magnethermic Corp. has announced a new line of aluminum billet heaters. This Model CSC has an improved coil design, a new billet stop and thermo-

couple assembly, rounded corners and built-in capacitors. It is available in all models up through 350 kw. and will be available up to 650 kw. by October.
For further information circle No. 5 on literature request card, p. 32-B.

Cleaning Solvent

Development of new and improved solvent to replace carbon tetrachloride in cleaning operations has been announced by Turco Products, Inc. It is nonexplosive and noninflammable —flash point over 200°F. Turco-Solv evaporates quickly and dries out completely without leaving residues to impair paint adhesion or to pick up carbon dust, metallic particles or other contaminants. The solvent is suited for many maintenance cleaning jobs. It may be used for hand wiping of small parts, precleaning prior to flaw-detection operations or for final clean-up of fabricated units.
For further information circle No. 6 on literature request card, p. 32-B.

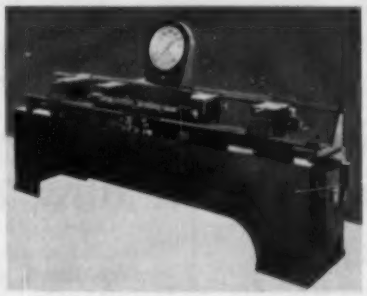
Crack Depth Measurement

Magnaflux Corp. has announced a seam depth indicator which can detect and measure the depth of cracks in iron and steel parts. It is a portable electronic instrument with a scanning probe on a 10 ft. cable. Relatively symmetrical parts can be scanned automatically while in other cases hand scanning is more practical. The Sedac SE-100 will locate and measure the depth of defects from 0.012 to 0.120 in. deep. Larger cracks are detected but their size over 0.120 in.

is not measured. By comparison with the known sample provided, it can be calibrated to find only cracks deeper than a pre-selected allowable minimum. The instrument can be used on flat pieces and curved surfaces with a 3⅛ in. or larger radius.
For further information circle No. 7 on literature request card, p. 32-B.

Tensile Testing

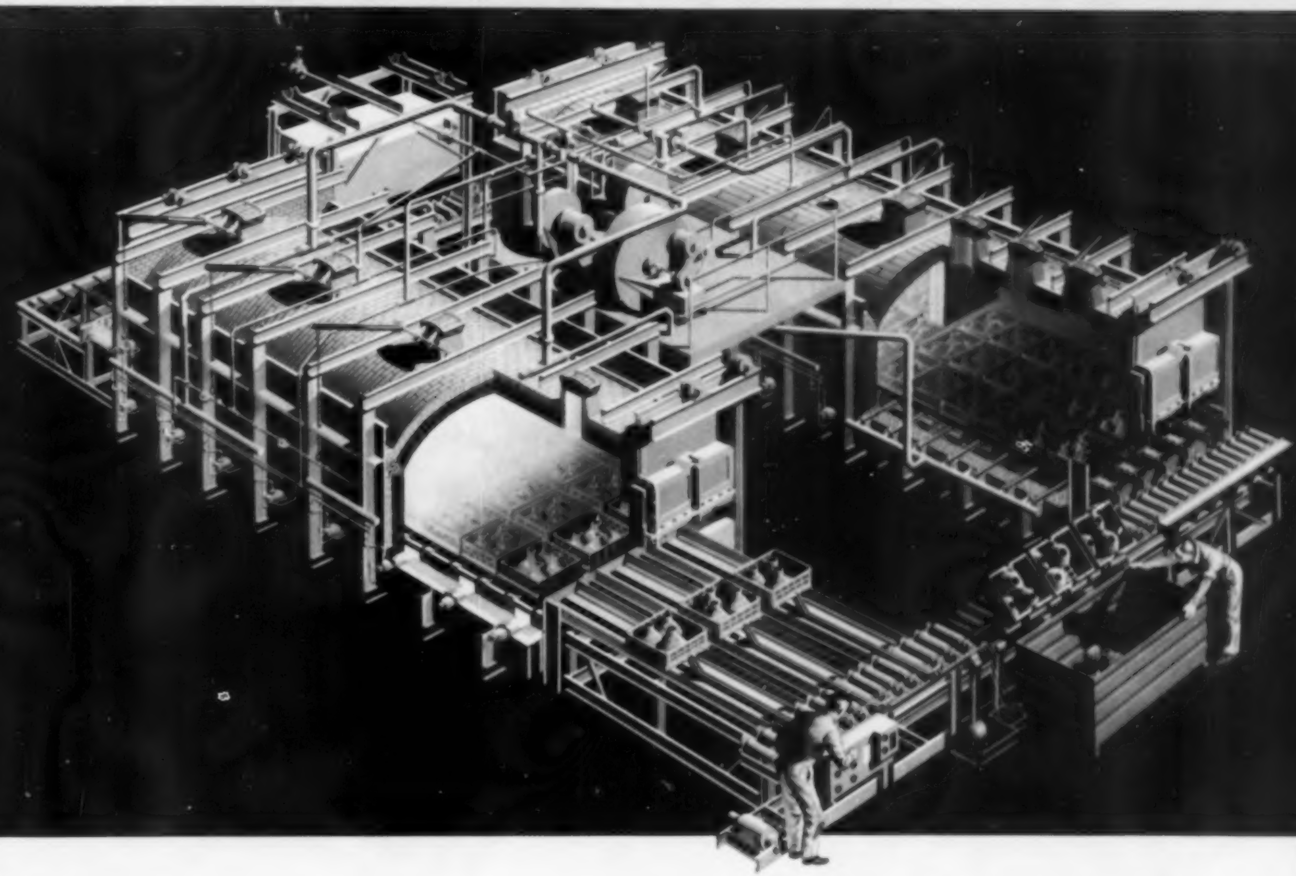
Detroit Testing Machine Co. has announced a 100,000 lb. capacity tensile testing machine for testing the butt welds in the thin wall square tubing. It tests both 2⅛ and 3⅛ in. square tubing without alteration, be-



cause it has two stations, one on each side. The difficulty in holding this kind of specimen was overcome with an hydraulically operated mandrel and gripping device. The machine is available with either one or two stations, and may be had with specimen holding devices for square, rectangular, round or oval tubes.
For further information circle No. 8 on literature request card, p. 32-B.

Welding

A new, automatic welding process which uses carbon dioxide gas for shielding the arc while welding mild and medium carbon steel, has been announced by the A. O. Smith Corp. It is similar in operation to the shielded inert-gas metal-arc process. The C-omatic process offers the advantage of low-cost automatic welding plus the benefit of a visible arc, which enables the welder to properly locate the arc in the welding groove and observe the weld metal being deposited.



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a perfect score!


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SKILLED MEN WITH FINE TOOLS AND ABLE SUPERVISION *CAN MAKE* 100% SCORES IN *SAFETY* AND IN QUALITY. At A.E.C.CO. they do, as this award — "Tops" in our industry — testifies. A.E.C.CO. craftsmen think! They take the same 100% care of your work in our shop that they do of themselves. *We* do *not* cut corners to make a "cheap" product. Such men don't live off the "price buyer."

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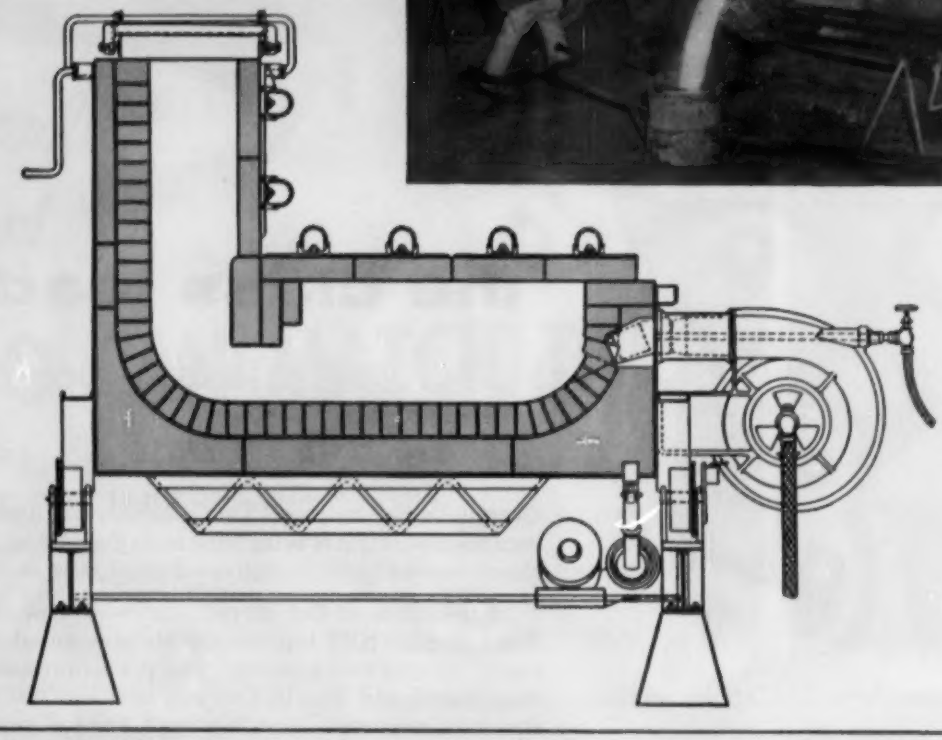
Another Norton ℞ on the job!

CRYSTOLON* baffle plates contribute to the high melting efficiency of Reda reverberatory furnaces

Reladling ductile iron from a Reda reverberatory furnace for ferrosilicon addition. These furnaces are designed for fast, low cost melting of both ferrous and non-ferrous alloys.



Cross-section of a reverberatory furnace manufactured by the Reda Pump Co. of Bartlesville, Okla. Charge is through the stack and the metal is heated by direct impingement of the flame passing over the metal bath and by reflected heat from roof and side walls. Melting takes place at base of stack, where CRYSTOLON baffle plates (shown in color) are the Norton ℞ — an expertly engineered refractory prescription — for this critical spot.

CRYSTOLON refractory material is *engineered* to combine great physical strength with exceptional resistance to thermal shock, slag penetration and chemical attack. It will withstand temperatures up to 3050°F, and has up to 15 times the resistance of ordinary fire clay to erosion and corrosion.

That is why CRYSTOLON baffle plates were *prescribed* for Reda furnaces — adding another to the long list of highly successful Norton ℞'s for the metal melting field.

Whatever your own furnace operations may be, there is a Norton ℞ that will help you to save time, labor and money. For information about Norton CRYSTOLON*, ALUNDUM*, MAGNORITE* and FUSED STABILIZED ZIRCONIA refractories — standard or special shapes or cements — see your Norton representative. Or write to NORTON COMPANY, Refractories Division, 328 New Bond Street, Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto 5, Ontario.

NORTON

REFRACTORIES

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Making better products... to make your products better

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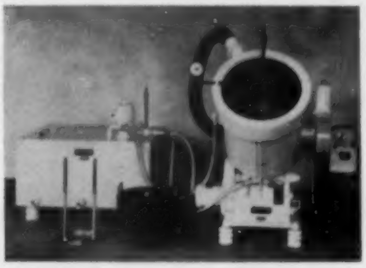
There is no need for flux and the attendant cleanup time that is required. Welds made with carbon dioxide gas have a wide and well rounded bead penetration. Filler wire of special formulation is fed to the welding head by means of rollers at controlled feed speeds. The head can be easily adjusted for welding in any position.
For further informaton circle No. 9 on literature request card, p. 32-B.

Chromium Plating

Barrel-type chromium plating machines which do away with racks or fixtures in the plating of small parts have been announced by the Dawson Corp. These barrel platers are available in three general types. The first has a capacity of approximately 1¼ gal. and can be used for short or intermittent plating of very small



pieces. The second has an approximate capacity of 10½ gal. and is intended for a variety of parts and for long production runs. It is equipped with a vapor exhaust and either a water jacket for cooling or a reserve tank through which the solution is circulated. The third, or automatic model, is continuous in operation and therefore suited for mass production. This machine has a capacity of approximately 13 gal. and a plating cycle averaging 8 to 10 min. and can produce up to 85 lb. of chromium plated parts an hour.
For further information circle No. 10 on literature request card, p. 32-B.

Thermocouple Restorer

The Restorer, for correcting inaccurate temperature reading and control caused by thermocouple circuit failure during heat treating and melting operations, has been announced by the Peerless Electric Co. Special electric impulse renews proper conductivity in thermocouple circuits by breaking down excessive resistance caused by corroded, oil-soaked or loose circuit connections. This permits pyrometers and controls to obtain proper thermoelectric voltages from the couple and assures accurate temperature reading and control during heats. The Restorer operates manually or automatically. It mounts

on existing pyrometer panels or on its own central control panel when many thermocouples are monitored in an instrument room.
For further information circle No. 11 on literature request card, p. 32-B.

Etcher

Buehler, Ltd., has announced a new Micromet etcher for electrolytic etching of metallographic specimens. It is always ready to operate, eliminating hook-ups and delays due to battery

failure. It is equipped with twin-type 0 to 5 volt d.c. voltmeter and a double scaled ammeter shunted for 0 to 100 milliamp. d.c. operation. Identified leads for the cathode and the anode with forceps for contacting or holding the specimen are supplied.
For further information circle No. 12 on literature request card, p. 32-B.

Lubricant

A molybdenum disulphide solid lubricant for dry operations has been

announced by Product Techniques, Inc. High purity molybdenum is ground to an average particle size of 0.6 micron. The powder is then combined with appropriate carriers, dispersants and drying agents. Moly Spray is recommended for machine tools, open mechanisms, sheet metal and tube bending operations.
For further information circle No. 13 on literature request card, p. 32-B.

Testing Machine

Taber Instrument Corp. has announced its new instrument for measuring hardness and lubricity of metals. The Dyhedron is a dynamic hardness tester and utilizes a selected octahedral diamond precisely shaped to work itself into the test material with a rotary oscillating motion. The depth of penetration is read from a precision dial indicator and the 360 deg. oscillations of the diamond are read from the rotary counter.
For further information circle No. 14 on literature request card, p. 32-B.

High Vacuum Pump

A new diffusion-ejector pump which will remove 12½ lb. of air per hour from a semi-continuous, vacuum melting and casting furnace has been announced by Consolidated Vacuum

Corp. The pump removes air at a speed of 18,000 liters per sec. and pumps hydrogen at a speed of 42,000 liters per sec. Its wide performance range permits diversified application. A single unit will handle the gas load of a 1000-lb., high vacuum, melting and casting furnace.
For further information circle No. 15 on literature request card, p. 32-B.

Filter

Industrial Filtration Co. has announced a new automatic Roto-Gravity filter, the major features of which are a permanent-type filter screen for removal of particles to 0.002 in. in size and large flow capacity. The unit is self-cleaning through reverse flush principle operating on a time lapse sequence. Residue thus cleaned from bar stock-type screen is removed by chain driven flights. One unit is mounted in tank to fit around base of Cincinnati grinder. Tanks of special design are available.
For further information circle No. 16 on literature request card, p. 32-B.

Heat Treating Baskets

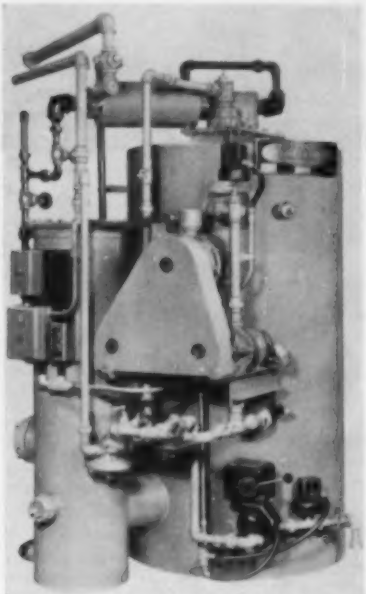
Inconel baskets and frames for use in heat treating have been announced by Wiretex Mfg. Co. Heat treating time was cut by over 50% at Ductile Iron Foundry where they have been put into use. The baskets have a solid wall and a screen covered grate

bottom, through which heat is forced. Each basket has two outside trunnions for handling by a crane. The carrier is designed to hold four baskets at one time and 300 lb. of castings are accommodated in each basket comprising a total load of 1200 lb. of castings for each assembly.

For further information circle No. 17 on literature request card, p. 32-B.

Gas Generator

A new exo-endothermic gas generator to provide gas atmosphere for heat treat furnaces has been announced by Holcroft and Co. The generator requires only 20 sq. ft. of floor space and can be used with all types of furnaces. It can produce gas atmospheres between the limits of perfect combustion and modified AGA Type 302. The gas generated differs from a standard AGA Type 302 gas in that it has a lower dewpoint (as low as minus 50° F. with no detectable amounts of methane) and it has approximately 50% lower



hydrogen content. With a slight adjustment the generator can produce a nonexplosive atmosphere for heat treating below the explosive limits required for atmosphere tempering, annealing, and stress relief of ferrous alloys as well as hardening, annealing and tempering of nonferrous alloys.

For further information circle No. 18 on literature request card, p. 32-B.

Thermometer Elements

Charles Engelhard, Inc., has announced a new glass protected, platinum wound resistance spiral which is used for precise temperature measurement over the range of —200 to 550° C. A special high temperature resistance element encased in an appropriate ceramic envelope is available for measuring temperatures up to 750° C.

For further information circle No. 19 on literature request card, p. 32-B.

Forging Furnace

Morrison Engineering Corp. has announced a new slot fired forging furnace for heavy-duty, continuous service at forging temperatures of 2300° F. and above. Other heating operations can be performed. The application of an automatic proportioning mixer and special burner equipment are featured.

For further information circle No. 20 on literature request card, p. 32-B.

Extensometer

A new nonaveraging, snap-on Microformer-type extensometer for use on small size round specimens has been announced by Baldwin-Lima-Hamilton Corp. It has short gage lengths and interchangeable attach-

ments for three different gage lengths: ⅛, ¾ and 1 in. Specimens may be from ⅛ to ¼ in. in diameter. The new extensometer is intended for use with miniature variable-trans-

former-type recorders to determine such elastic properties as offset yield strength. Strain magnifications are 250, 500 and 1000 to 1 with a measuring range of 0.02 in.
For further information circle No. 21 on literature request card, p. 32-B.

Refractory Fiber

Babcock & Wilcox Co. has announced new uses for Kaowool, a high-temperature refractory fiber, made of kaolin clay. The clay is elec-

trically melted and then the molten material is blown into fibers which are collected on a pad-forming conveyor. The long-fibered insulating wool can be used as a furnace lining.
For further information circle No. 22 on literature request card, p. 32-B.

Temperature Meter

A new portable temperature meter with a wide range from −50 to +1000° F has been announced by Webber Gage Co. Fitted with a sensitive thermocouple, the instrument measures temperatures of metals, liquids and air, and eliminates delays caused by waiting for gage blocks or work to return to normal temperature. Temp-Check

operates on a flashlight battery and is portable.
For further information circle No. 23 on literature request card, p. 32-B.

Vacuum Furnace

A new 50-lb. vacuum skull-type arc furnace has been announced by Naresco Equipment Corp. It is a completely self-contained furnace for development and small-scale production

purposes and is particularly suited for melting titanium, for either scrap recovery or for casting.
For further information circle No. 24 on literature request card, p. 32-B

Steam Cleaners

Kelite Products has announced a new model K line of steam cleaners. They are gas or oil fired and come in capacities to 300 gal. per hr., with super duty models to 3000 gal. per hr. The heat exchanger raises the water temperature to 100° F. before the water enters the main heating circuit. This is accomplished by trapping waste heat, thus reducing fuel consumption. The automotive-type piston pump runs in oil and has stainless steel ball check valves. The straight-line cabinet requires no clay or firebrick and is louvered for adequate ventilation.
For further information circle No. 25 on literature request card, p. 32-B

What's New in Manufacturers' Literature . . .

42. Abrasive Wheels
Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

43. Alloy Chart
Comparison of AISI, SAE, ACI, AMS, WAD and PWA chromium and chromium-nickel stainless specifications. *Cannon-Muskegon*

44. Alloy Steel
207-page book gives more than 50 complete case histories of alloy steel usage. *Climax Molybdenum*

45. Alloy Tools
44-page book on cast Stellite tools for metal cutting. *Haynes Stellite*

46. Aluminum
4-page folder on standard and flattened expanded aluminum gives sizes, dimensions, weights for different mesh sizes. Applications. *Penn Metal Co.*

47. Aluminum Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

48. Aluminum Extrusions
28-page book on extruded aluminum products. Design, tolerances, applications. *Revere*

49. Aluminum Forgings
12-page booklet on press forgings, impact extrusions and hand forgings. Properties of aluminum forging alloys. *Harvey Aluminum*

50. Aluminum Strip
20-page booklet on how it is made, sizes and weights of coils. Technical data on aluminum alloys used. *Scovill*

51. Aluminum Welding
Data on chemical composition of aluminum welding rods and electrodes. *Arcos*

52. Analysis of Nickel Alloys
52-page Technical Bulletin T-36, "Methods for Chemical Analysis of Nickel and High-Nickel Alloys." *International Nickel*

53. Anodized Aluminum
Booklet on latest developments in coloring anodized aluminum. *Sandoz Chemical Works*

54. Atmosphere Furnace
Information on mechanized batch-type atmosphere furnaces for gas cyaniding, gas carburizing, clean hardening or carbon restoration. *Dow Furnace*

55. Atmosphere Furnace
12-page bulletin on electric furnaces with atmosphere control for hardening high speed steel. *Sentry*

56. Atmospheres
Bulletin 1-10 supplies technical information on inert gas generators and data on costs. *C. M. Kemp Mfg.*

57. Atmospheres
12-page booklet on design and use of special atmospheres for industrial furnaces. *Continental Industrial Engineers*

58. Bearings
20 data sheets give special properties and case histories for new Rulon oil-free bearing material. *Dixon Corp.*

59. Beryllium Copper
Bulletin 1 on available alloys, conditions, tempers and tables of sizes and properties. *Penn Precision Products*

60. Black Oxide Coatings
8-page booklet on black oxide coatings for steel, stainless steel and copper alloys. *Du-Lite*

61. Boiler Refractories
New 20-page bulletin on boiler refractories discusses basic requirements of refractories, what causes refractories to fail, various kinds of insulating firebrick. *Refractories Div., Babcock & Wilcox*

62. Boron Additive
6-page article on use of grainal as boron-additive alloy and properties of grainal steels. *Vanadium Corp.*

63. Brass Bearings
New 24-page catalog on 600 series bearing alloys. Description of alloys, typical parts, properties, machining. *Mueller Brass*

64. Brazed Tubing
12-page data book on brazed tubing made from copper coated steel. *Bundy*

65. Brinell Machine
Data on semi-automatic Brinell testing machine. *Detroit Testing Machine*

66. Brush Selector
Setting selector at brush diameter, selection may be made in choice of steel, stainless, phosphor bronze, tampico or cord. *Fuller Brush Co.*

67. Carbon and Graphite
20-page catalog on carbon and graphite applications in metallurgical, electrical, chemical, process fields. *National Carbon*

68. Carbon Control
Bulletin SC-168 on system for automatically controlling carbon potential in continuous and batch furnaces. *Surface Combustion Corp.*

69. Carbon Control
Bulletin C-22 and reprint on Carbotronik for automatic control on carbon potential of atmospheres. *Ipsen*

70. Carbonitriding
Bulletin 241 on gas-fired radiant-tube furnace for carbonitriding and other heat treating. *Lindberg Engineering*

71. Carburizing
16-page booklet on gas-carburizing processes and equipment. Discussion of suspended carburization, carbon restoration. *Surface Combustion*

72. Carburizing Salts
Folder on salts for liquid carburizing. *Swift Industrial Chemical*

73. Castings
Bulletin on Ellis casting process, a new method for casting electronic components. *Howard Foundry*

74. Castings, Bronze
16-page booklet on sand and centrifugal castings. *American Non-Gran Bronze*

75. Charging
12-page brochure on eight models of charging machines for heating and melting furnaces. *Salem-Brosius*

76. Chromate Finishing
File on chromate conversion coatings for prevention of corrosion and paint-base treatment of nonferrous metals. *Allied Research Products*

77. Chromium Plating
Booklets on how to chromium plate and anodes for the process. *United Chromium*

78. Chromium Stainless
12-page book on fabrication and use of Type 430 stainless steel. *Sharon Steel*

41. Definitions
Steel terms of particular value to men who buy or use cold finished steel bars are defined in this 32-page dictionary. It includes more than 180 definitions from annealing and austempering through isothermal quenching and macroetching to spheroidizing,

stress relieving and yield strength. Many of the definitions are taken from the ASM Metals Handbook and these are marked with an ● symbol. Figures and tables cover such subjects as standard grain sizes for steels, Shepherd grain size fracture standards, hardness conversions, iron, iron carbide equilibrium diagram and others. *La Salle Steel Co.*

79. Cleaner
Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

80. Cleaning
New 40-page catalog on detergents, wetting agents, brighteners and other chemicals. *Antara Chemicals*

81. Cleaning
32-page booklet on alkaline, solvent, emulsion, acid phosphate cleaning. *E. F. Houghton*

82. Cleaning
44-page booklet, "Some Good Things to Know About Metal Cleaning," discusses tank, barrel and machine cleaning, pick-

Another Norton ℞ on the job!

One of the 1200-pound Ajax induction furnaces used by The Duriron Company, Inc. of Dayton, Ohio. Melts are chiefly stainless steel alloys, tapped at 3200°F or higher.

MAGNORITE cement, the Norton ℞ for lining and patching these furnaces, has resulted in substantial savings — not only in the amount and cost of cement, but in time and labor.

The Duriron Company, Inc. doubles heats-per-lining, cuts melting costs, maintains stainless steel quality with MAGNORITE cement*

If re-lining is too frequent a job in your induction furnace operations — if you're using up too much time, cement and money to get maximum heats — we suggest you consider MAGNORITE cement.

Take the experience of The Duriron Company, leading manufacturers of chemical process equipment made of stainless steel and other metals. Before trying MAGNORITE cement, their best previous lining material was giving an average of 68.2 heats per lining. Thorough test runs of MAGNORITE at the Duriron foundry show this Norton refractory material is averaging 140.5 heats per lining. And it is not only lasting twice as long as its best performing competitor, it is more refractory, it has 50% less slag volume on heats, and its freedom from shrinkage eliminates cracking. Another instance of how Norton refractories and refractory materials are *engineered and prescribed* to provide time-and-money-saving ℞'s.

Give MAGNORITE cement a test run

in one of your own furnaces. Note how it withstands temperatures up to 3250°F — how its high-rammed density resists metal penetration, erosion and chemical attack — how its slight expansion when sintered eliminates shrinkage cracks in the crucible lining.

Norton will be glad to specify MAGNORITE cement to your exact requirements, or to help you solve metal-melting problems. Working with MAGNORITE*, ALUNDUM*, CRYSTOLON* and Fused Stabilized Zirconia cements, Norton engineers will find ℞'s you need for efficiency and economy. For details, see your Norton Refractories Engineer, or write to NORTON COMPANY, Refractories Division, 327 New Bond Street, Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.

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ling, zinc phosphate coating, rust prevention and other processes. *Oakite*

83. Cleaning
28-page catalog, B-9, on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

84. Coatings
Data sheet on industrial Protectox, tarnish-resistant coating for silver, silver alloys, copper, brass and gold. *Technic*

85. Cold Finished Steel
16-page booklet on 10 grades of cold finished steels. Analysis, machinability, heat treatment, wear resistance. *Jones & Laughlin*

86. Cold Rolled Steels
32-page booklet on stainless, alloy and carbon spring steels, and other specialties. Melting, temper, finishes. *Crucible Steel*

87. Colored Coil
Folder on aluminum, steel or other metallic coil finished in permanent colors. *Southern States Iron Roofing Co.*

88. Combustion Control
20-page booklet on combustion of various fuels and portable instrument to measure content of oxygen and combustibles. *Cities Service Oil*

89. Compressors
12-page data book 107-D gives engineering information on characteristics of turbo-compressors. 18 types of application described. *Spencer Turbine*

90. Controlled Atmospheres
Bulletin on Dewpointer for reading of atmosphere in field and laboratory. Readily portable, operating on a.c. or enclosed battery. *Illinois Testing Labs.*

91. Copper Alloys
64-page book on free-cutting brass, copper and bronze. *Chase Brass*

92. Corrosion Resistant Alloy
Data sheet compares corrosion properties of Elgiloy and stainless steel. *Elgin National Watch Co.*

93. Degreasing
34-page booklet on vapor degreasing. Design, installation, operation and maintenance of equipment. *Circo Equipment*

94. Degreasers
Bulletin on 2 and 3-dip degreasers. *Randall Mfg. Corp., Ramco Equipment*

95. Descaling Stainless Steel
Bulletin 25 on descaling stainless steel and other metals in molten salt. *Hooker Electrochemical*

96. Die Castings
Booklet on small zinc die castings. For designers and engineers. *Gries Reproducer*

97. Electric Furnaces
Brochure on electric heat treating, melting, metallurgical tube, research and sintering furnaces. *Pereny Equipment*

98. Electric Furnaces
Bulletin 441 on box-type electric furnace diagrams and describes the furnaces and lists specifications. *Hevi Duty Electric Co.*

99. Electric Furnace
Bulletin on box-type, pre-heat and hardening furnace with automatic atmosphere contamination control. *Pacific Scientific*

100. Extrusion Presses
8-page bulletin on aluminum extrusion presses describes the process and presses at work. *Watson-Stillman*

101. Finishing
Two 8-page bulletins on dip tank and flow coat finishing describe processes, advantages and disadvantages of two processes. *Du Pont Finishes Div.*

102. Finishing
52-page book "Advanced Speed Finishing" describes equipment for deburring and finishing. *Almco Div.*

103. Flame Plating
16-page booklet lists advantages, properties, specifications of flame-plated tungsten carbide coating. *Linde*

104. Flaw Location
12-page booklet on dye penetrant inspection method. Suggestions on how to perform inspection by this method. *Turco Products, Inc.*

105. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Eng'g*

106. Fluoroscopy
12-page booklet on fluoroscopy for nondestructive internal inspection. Explains image amplifier. *Westinghouse Electric, Industrial X-Ray Dept.*

107. Fluxes
8-page bulletin on fluxes for aluminum casting and how fluxes help strengthen aluminum alloys. *Apex Smelting*

108. Forgings
94-page book on die blocks and heavy-duty forgings. 20 pages of tables. *A. Finkl & Sons*

109. Forgings
Handsome 32-page brochure on large forgings for turbine shafts, rotors, drop hammer anvils, rolls. *U. S. Steel*

110. Forgings
New bulletin on forge steel making, open die forging, machining, heat treating and finishing. *National Forge*

111. Furnace Belts
44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

112. Furnaces
Series of bulletins on controlled atmosphere, carburizing, nitriding, hardening furnaces. *American Gas Furnace*

113. Furnaces
Catalog on furnaces for tool room and general purpose heat treat. *Cooley*

114. Furnaces
6-page folder on gas-fired, oil-fired and electric furnaces. Typical installations. *Electric Furnace*

115. Furnaces
Folder describes complete set up for heat treatment of small tools, including draw furnace quench tank and high temperature furnace. *Waltz Furnace*

116. Furnaces
Bulletin on electric heat treating furnaces describes five series and accessories. *Lucifer Furnaces*

117. Furnaces
Data on luminous wall forging furnaces. *A. F. Holden*

118. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

119. Fused Silica
Folder on fused silica which is resistant to high temperatures, thermal shock, acids and has high electrical insulating value. *Amersil*

120. Galvanizing
Reprint "Modern Hot-Dip Galvanizing" deals with dross formation as a cause of zinc waste. *Hanson-Van Winkle-Munning*

121. Gas Analysis
Data on positive, nondispersion-type infrared analyzers for laboratory and industry. *Minneapolis-Honeywell*

122. Gear Tester
New bulletins on testing machines for roll testing of spur, worm, spiral and bevel gears. *Geo. Scherr Co.*

123. Gold Plating
Folder on salts for bright gold plating. Equipment needed. *Sel-Rex*

124. Graphite Electrodes
Vest-pocket notebook containing 90 pages of information on electric furnace electrodes and other carbon products. *Great Lakes Carbon Corp.*

125. Handling Devices
Pamphlets on clamps for lifting and handling. Their application to various industries. *Merrill Bros.*

126. Hardness Tester
Bulletin on Impressor portable hardness tester for aluminum, aluminum alloys and soft metals. *Barber-Colman*

127. Hardness Tester
20-page book on hardness testing by Rockwell method. *Clark Instrument*

128. Hardness Tester
20-page bulletin on use of portable hardness testers and accessories. *Ames Precision Machine*

129. Hardness Tester
New 4-page folder on portable Brinell hardness tester which can be used in any position. Details of machine and its operation. *Andrew King*

130. Hardness Tester
4-page bulletin on tester for both superficial and regular hardness testing. *Torsion Balance Co.*

131. Hardness Tester
Bulletin RH-12-54 on portable hardness tester for Rockwell readings. *Riehle*

132. Heat Processing
Bulletin answers questions: What is to be heated, what sections are to be heated, why the material is to be heated, to what temperature and for how long. *Selas*

133. Heat Resistant Alloy
10-page article on how to get best service out of standard grades of heat resisting alloys by proper selection. *Rolled Alloys*

134. Heat Treating
Bulletin describes baskets, crates, trays, furnace parts for heat treating. *Stanwood*

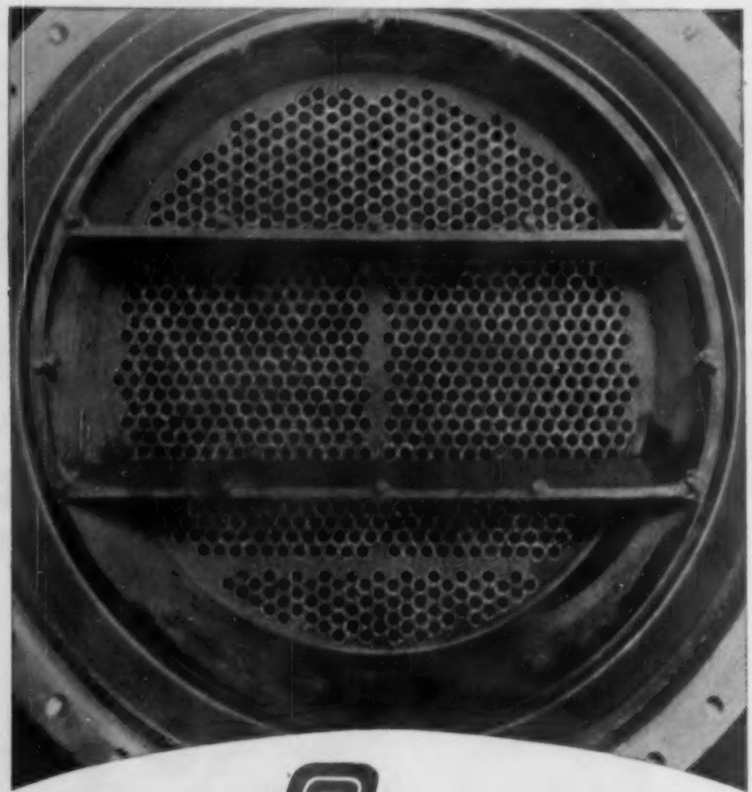
135. Heat Treating Baskets
12-page bulletin on wire mesh baskets for heat treating and plating. *Wiretex*

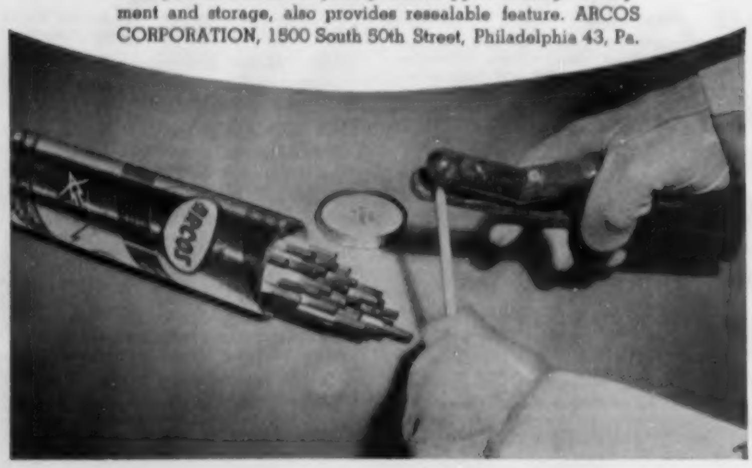
136. Heat Treating Fixtures
New folder on carburizing boxes, trays, heat treat fixtures and baskets. *Misco*

137. Heat Treating Fixtures
24-page catalog on heat and corrosion-resistant equipment for heat treating and chemical processing. 30 classifications of equipment. *Pressed Steel*

138. Heat Treating Furnaces
12-page booklet on various heat treating furnaces contains chronology of advances in heat treating furnaces. *Holcroft*

139. Heaters
New folder on uses and various forms of fused quartz radiant heaters. *Cleveland Process Co.*





140. High-Strength Steel
48-page book on T-1 steel, its properties and applications. *U. S. Steel*

141. High-Temperature Alloy
Property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

142. High-Temperature Alloys
Booklet "Keep Operating Costs Down When Temperatures Go Up." *International Nickel*

143. High-Temperature Lubrication
Bulletin on colloidal graphite lubrication of kiln cars, oven conveyors and forging dies. *Acheson Colloids*

144. High-Vacuum Furnaces
12-page brochure No. 790 on vacuum furnaces for melting and casting titanium, zirconium, germanium, copper, iron and steel. Also furnaces for annealing, hardening, brazing. *F. J. Stokes*

145. Hydride Descaling
24-page book "Handling Metallic Sodium" with special reference to sodium hydride descaling. *U. S. Ind. Chem.*

146. Indicators
Folder on dial indicators describes mechanism and gives specifications. *Nilsson Gage Co.*

147. Induction Heat Control
Data sheet on radiation pyrometer for direct measurement of work being induction heated. *Leeds & Northrup*

148. Induction Heaters
New 12-page bulletin on low-frequency (60-cycle) induction heating furnace for nonferrous metals. *Magnethermic*

149. Induction Heating
60-page catalog tells of reduced costs and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

150. Induction Heating
8-page bulletin on forging with induction heat includes case histories, benefits to the forging industry. *General Electric*

151. Induction Heating
12-page bulletin B-6519 on motor generator sets, r.f. generators, work stations, handling equipment. *Westinghouse Electric*

152. Induction Melting
8-page bulletin 27-B on induction equipment for melting, forging and heating. *Ajax Electrothermic*

153. Industrial Fans
Catalogs on various kinds of industrial fans — exhaust, multiblade, backward curve, for high temperatures. *Garden City Fan*

154. Industrial Radiography
Booklet gives recommendations on planning and construction of a betatron industrial radiograph laboratory. *Allis-Chalmers Mfg.*

155. Instruments
Bulletin F-5633-1 on instruments for industrial process control. *Wheelco*

156. Interference Microscope
Bulletin B-602 describes new Zeiss instrument for fast nondestructive examination and photography for wave-length measuring of surface finishes in the order of one millionth of an inch down to 300 Angstroms. *Boder Scientific Co.*

157. Investment Casting
New bulletin on gas fired furnaces for investment casting. Also includes chart of characteristics of typical investment casting alloys. *Surface Combustion*

158. Investment Castings
Chart of standard investment casting alloys gives compositions and properties of stainless, low-alloy and tool steels, nickel, copper base and aluminum alloys that are suited to the process. *Precision Metalsmiths*

159. Laboratory Furnaces
26-page, "Construction of Laboratory Furnaces," contains many diagrams, charts, tables and information on how to construct furnaces. *Norton*

160. Laboratory Tubing
Bulletin on precision-bore tubing of fused quartz or glass. Shapes, properties. *Fischer & Porter*

161. Leaded Steel
8-page booklet on production of lead treated steels, their advantages and case histories of their use. *Copperweld Steel*

162. Leaded Steel
8-page bulletin gives chemical composition, mechanical properties and case studies showing machining production rates of Ledloy, lead bearing steel. *Ryerson*

163. Leak Detector
16-page bulletin on leak detector for location and measurement of leaks in evacuated or pressure systems. *Consolidated Vacuum Corp.*

164. Light Metal Heating
New booklet on ovens for heat processing of aluminum, magnesium and titanium. *Michigan Oven.*

165. Low-Carbon Stainless
"Melting Low-Carbon Stainless Steel" shows advantages in use of new low-carbon chromium alloy for producing extra-low-carbon grades. *Electro Metallurgical*

166. Lubricant
Bulletin 104 on microsize powder of molybdenum disulphide lubricant. *Alpha Corp.*

167. Machining Alloy Steels
24-page bulletin on economical combination of microstructure, tool form, cutting speed and feed for each machining operation. *International Nickel*

168. Machining Costs
12-page "Relation of Machining Time to Material Cost." Comparative machinability costs per ton for eleven steels. *La Salle Steel*

169. Magnesium
42-page booklet on wrought forms of magnesium. Includes 31 tables. *White Metal Rolling & Stamping*

170. Mechanical Cleaning
6-page folder on a brushing lathe and universal work piece holder. *Fuller Brush*

171. Mechanical Cleaning
Booklet on how brushes are used for cleaning welds, stainless sheets, hot cast iron, automotive parts, brass fixtures. *Pittsburgh Plate Glass, Brush Div.*

172. Melting Furnace
Bulletin gives specifications, diagrams, performance and other technical data on Simplex melting furnaces. *Lindberg Engineering*

173. Melting Guide
Selector guide for heating equipment and control for solder, tin and lead melting. *General Electric Co.*

174. Metal Cutting
64-page catalog No. 29 gives prices and describes complete line of rotary files, burrs, metalworking saws and other products. *Martindale Electric*

175. Metal Powders
168-page catalog, B-44, on bronze and

ferrous alloys. Engineering data and information including design data, load capacities, specific properties, assembly procedure. *Amplex Div.*

176. Metalworking Machinery
142-page catalog on sheet metal machinery. *Federal Machinery Co.*

177. Metal Protection
New folder on adhesives, coatings and sealers for joint-sealing, bonding and protecting sheet metal. *Minnesota Mining and Mfg. Co.*

178. Microscopes
Catalog on metallograph and several models of microscopes. *United Scientific*

179. Nickel Alloys
40-page book gives corrosion, physical and mechanical properties of Hastelloy alloys; 13 pages of fabrication data. *Haynes Stellite*

180. Nitriding
New 48-page booklet on nitralloy and nitriding, including the new Floe process. Seventeen charts and five graphs give mechanical properties and case hardening capabilities of four principal types of nitralloy steels. *Nitralloy Corp.*

181. Nitriding Furnace
Bulletin 646R on carburizing and nitriding furnace giving atmosphere circulation to 1850° F. *Hevi Duty*

182. Nodular Iron
8-page bulletin on nodular iron rolls and castings gives description and specifications for nodular iron, and how it is cast. *Aetna-Standard Engineering*

183. Nondestructive Testing
8-page bulletin on equipment for nondestructive testing of bars, rods, tubing. *Magnetic Analysis*

184. Nonferrous Casting
Folder on sand castings of bronze, aluminum and magnesium. *Springfield Bronze and Aluminum Co.*

185. Nonferrous Wire
Folder gives wire gage and footage chart and data on beryllium copper, phosphor bronze, nickel, silver, brass and aluminum wire. *Little Falls Alloys*

186. Nonflammable Rust Preventive
Bulletin on rust preventive compound which is water soluble, nontoxic and nonflammable. *Production Specialties*

187. Nuclear Radiation Cell
Data on industrial instrumentation applications of the Ohmart cell, the radioactive sensitive element which converts nuclear radiation into electrical energy. *Minneapolis-Honeywell*

188. Oil Quenching
Catalog V-1146 on self-contained oil cooling equipment. Selection tables for volume of oil required and oil recirculation rates. *Bell & Gossett*

189. Ovens
New Bulletin 10-S on cabinet ovens describes those for use with gas, electric and steam heat for temperatures to 600° F. *Young Brothers.*

190. Ovens
16-page bulletin No. 53 on various types of core and mold ovens, special ovens and heat treating furnaces. *Carl Mayer*

191. Parting Compound
Folder on use of colloidal graphite as a parting compound. *Acheson Colloids*

192. Photomicrography
Catalog E-210 on sliding base, high or low power photomicrographic equipment. *Bausch & Lomb*

193. Pickling Baskets
12-page bulletin on mechanical picklers,

(Continued on p. 32A)

(Continued from p. 31)
crates, baskets, chain and accessories. *Youngstown Welding & Eng'g*

194. Pickling Baskets
Data on baskets for degreasing, pickling, anodizing and plating. *Jelliff*

195. Plating
Bulletin CR-110-5 describes equipment, bath, operating conditions and control of high-speed chromium plating process. *United Chromium*

196. Plating Equipment
16-page bulletin on anodes, anode accessories, plating processes and plating chemicals. *Hanson-Van Winkle-Munning*

197. Plating Filters
Bulletin HH103 on filters for plating solution clarification and carbon treatment. *U. S. Hoffman*

198. Plating Filters
7-page reprint on the use of filters in electroplating describes continuous, slurry tank, batch, sump and batch-sump filtration. *Alsop Engineering*

199. Plating Solutions
Bulletin 12 on electric heating of pickling and plating solutions. *Pyrosil*

200. Powder Metallurgy
New literature on advantages in powder metal parts. Flow chart of fabrication by process. *Hoeganaes Sponge Iron Corp.*

201. Powdered Metals
Bulletin 800-B on pre-alloyed iron powders with varied chromium-nickel contents. *Metal Hydrides*

202. Powdered Metals
Booklet tells how things are made of powdered metals, applications and future possibilities. *Stokes*

203. Precision Casting
New 16-page booklet on methods used to produce castings by the "lost wax" method. Compositions of alloys used. *Crucible Steel*

204. Precision Casting
8-page bulletin on investment castings of various ferrous and nonferrous alloys. *Engineered Precision Casting*

205. Precision Castings
20-page book on alloys used, specification ranges, advantages and castings made by precision casting. *Haynes Stellite*

206. Protective Coatings
Guide to chemicals and processes for metal protection. *American Chemical Paint*

207. Pyrometer Calibration
"Pyrometer Thermocouple Calibration Data" includes tables of data released by National Bureau of Standards. *Bristol Co.*

208. Pyrometer Supplies
New 16-page catalog or buyer's guide for thermocouples, protecting tubes, thermocouple wires, extension lead wires, insulators, pyrometer accessories. *A. S. Richards*

209. Quench Furnaces
Bulletin 700 on cataract quench furnaces for austempering and martempering. *Ajax Electric*

210. Quenching Oil
8-page booklet on applications and cost reductions in oil-quenching installations. *Sun Oil*

211. Radiography
16-page bulletin on materials and accessories for radiography. Density curves for four types of films. *X-Ray Div., Eastman Kodak*

212. Radiography
28-page booklet on products for industrial radiography gives exposure and processing data for various films used. *DuPont*

213. Refractories
New 24-page bulletin on physical and chemical properties of super refractories. Applications. *Refractories Div., Carborundum*

214. Refractories
Identification guide shows colors that identify the various types of basic refractory brick and lists ramming mixes, bonding mortars and furnace grains. *Kaiser Aluminum & Chemical*

215. Refractories
12-page brochure on products for casting special refractory shapes and for gunning and troweling applications, for services to 3000° F. *Johns-Manville*

216. Refractory
12-page bulletin CR-11 on new crystalite refractory gives properties, analyses, processing methods, uses. *Richard C. Remmey Son Co.*

217. Refractory
Bulletin No. 507 on high temperature silica cement for bonding silica and super-duty silica refractories. *Chas. Taylor Sons*

218. Refractory Cement
Bulletin discusses refractories and heat-resistant concrete. *Lumnite Div.*

219. Rhodium Plating
Booklet on rhodium plating as re
ment for usual plating metals. *Ba*
Co.

220. Roll Formed Shapes
24-page Bulletin 1053 on desi
forming and producing shapes fro
rous and nonferrous metals. *Roll F*
Products Co.

221. Roll Forming
Bulletin 854 on roll forming o
rolled shapes. *American Roller Di*

222. Salt Bath Furnaces
Data on electric, gas and atmos
salt baths. *Bellis*

223. Salt Bath Furnaces
Data on salt bath furnaces for
and conveyorized work. *Upton*

224. Salt Baths
32-page booklet on heat treat
liquid salt baths. Properties of
liquid baths. *E. F. Houghton*

225. Seamless Tube
Chart of grades, analysis, machin
forging temperatures, annealing, n
izing, carburizing, hardening proc
Babcock & Wilcox

226. Selective Hardening
Article on hardening 75 differen
in one heat treat department at
Cork & Seal Co. *Ajax Electric Co.*

227. Shell Molding
8-page booklet No. 2462 on au
shell molding system for produc
to 240 molds per hour. *Link-Belt*

228. Shot and Grit
Handy calculator has size data f
grades of shot and grit. *Pangborn*

229. Slitting
76-page book on slitting lines f
and sheets. Design, selection, op
time studies of operating cycle.

230. Sonic Thickness Te
Measurement of wall thicknes
one side by sonic method. *Brans*

231. Spark Testing
20-page spark test guide feature
diagrams of 13 standard tool a
steels. *Carpenter Steel*

232. Specifications Index
28-page cross index lists coppe
specifications of nine different
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233. Spectrogr Equipme
18-page catalog D and medium quart various accessories.

234. Spectrog
New 4-page bulle graphic source unit units available. *Ba*

235. Stainless
20-page catalog c screws, nuts, wash sheet metal screws, tings and specialties

236. Stainless
20-page book on u *Electro Metallurgica*

237. Stainless
New 36-page catal working stainless types of fabrication design for econom *penter Steel Co., A*

238. Stainless
New 32-page aid stainless steel wire cation discusses a martensitic grades.

239. Stampin
Bulletin on maki stampings per hour *Stampings Div.*

240. Steel
16-page booklet industry includes silicon, and tool terials, carbide met *Steel*

241. Steel 52
Data sheet on h made by vacuum m

242. Stress-St
New 28-page bu standard recorders followers, for use machines. *Baldwin*

243. Sub-Zer
New 12-page boo ing equipment for treating of metals. *Products*

244. Tempera
New 8-page bul control systems co terminology, type *Wheelco Instrume*

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Spectrographic Equipment
e catalog D-20 describes Littrow dium quartz spectrographs and accessories. *Bausch & Lomb*

Spectrographic Sources
4-page bulletin 35A on spectro- source unit gives data on three vailable. *Baird Assoc.*

Stainless Fastenings
ge catalog of stainless steel cap nuts, washers, machine screws, etal screws, set screws, pipe fit- d specialties. *Star Stainless Screw*

Stainless Steels
ge book on uses of stainless steels. *Metallurgical*

Stainless Tubing
36-page catalog on fabricating and stainless tubing and pipe. 11 fabrication are described. How to for economical fabrication. *Car- Steel Co., Alloy Tube Div.*

Stainless Wire
32-page aid to selection of proper s steel wire for particular appli- discusses austenitic, ferritic and sitic grades. *Crucible Steel*

Stampings
tin on making from 100 to 40,000 ngs per hour. *Laminated Shim Co., ngs Div.*

Steel
ge booklet on special steels for y includes stainless, electrical, and tool steels, magnetic ma- carbide metals. *Allegheny Ludlum*

Steel 52100
sheet on high-purity 52100 steel, y vacuum melting. *Vacuum Metals*

Stress-Strain Recorders
28-page bulletin No. 4215 on 16 d recorders and 50 models of strain rs, for use on standard testing es. *Baldwin-Lima-Hamilton*

Sub-Zero Treatment
12-page booklet on industrial chill- uipment for shrinking, testing and g of metals. *Cincinnati Sub-Zero ts*

Temperature Control
8-page bulletin on temperature systems contains selection guide, ology, types of control systems. *o Instrument Div.*

245. Test Accessories
22-page Bulletin 46 on instrumentation, tools and accessories for mechanical testing machines. *Tinius Olsen*

246. Tester
Bulletin 164 on Dyhedron, dynamic diamond tester for hardness and lubricity of materials. *Taber Instrument*

247. Testing Equipment
80-page illustrated catalog lists over 130 testing and measuring tools for laboratory and production-line use. *General Electric*

248. Testing Machine
8-page bulletin on SR-4 universal testing machine of 50,000 lb. capacity. *Baldwin-Lima-Hamilton*

249. Testing Machines
8-page folder on Amsler machines for tests in tension, compression, torsion, shear, fatigue, bending and ductility. Bulletins on wear testing and testing of miniature samples. *Buehler*

250. Textured Stainless
Folder on stainless to conserve alloys and reduce weight. *Rigidized Metals*

251. Thermocouple Wire
Bulletin on thermocouple wire and thermocouple extension wire lists sizes, metals, insulations. *Claud S. Gordon*

252. Tinning
Bulletin TC-43441 on electrotinning of copper wire. *Baker & Adamson Products*

253. Titanium Alloy
Data on ternary alloy with 3% aluminum and 5% chromium gives physical properties, forging temperatures, high temperature characteristics. *Mallory-Sharon Titanium*

254. Titanium and Zirconium
16-page bulletin, "The Hydrimet Process," on titanium and zirconium metals and hydrides, and other metallurgical hydrides. *Metal Hydrides*

255. Tool Steel
36-page booklet on properties and applications of high speed steels, nonferrous cutting materials and carbides. *Allegheny Ludlum*

256. Tool Steel
Properties and treatment of general-purpose air-hardening chromium-molybdenum tool steel. *Bethlehem*

257. Tool Steel
Data sheets on high speed, hot work, air, oil and water hardening tool steels, alloy steels, machinery steels, stainless steels, welding rods. *Crucible Steel*

258. Tubing
52-page "Handbook of Seamless Steel Tubing." 26 pages of data. *Timken*

259. Tukon Tester
12-page bulletin DH-114 on Tukon micro and macro hardness testers. *Wilson Mech. Inst.*

260. Tungsten Alloy
Data on properties and uses of 95% tungsten alloy, balance nickel and copper. *Firth Sterling*

261. Ultra Strength Steel
Results of three year research and test program evaluating properties of Type 4340 steel for aircraft structures. *International Nickel*

262. Vacuum Calculator
Slide rule for quick calculation of data necessary in vacuum engineering and processing—for instance, pump capacities and time to reach given vacuum. Pertinent conversion tables on back. *F. J. Stokes Machine*

263. Vacuum Melting
Bulletin on production and testing equipment for vacuum melting. Advantage. *Utica Metals Div., Utica Drop Forge & Tool*

264. Vacuum Metallurgy
Articles on commercial vacuum furnaces for metals and alloys and some aspects of vacuum melted metals. *National Research Corp.*

265. Welding
New 52-page catalog on gases, welding and cutting equipment and accessories for job shops, maintenance departments and other users of light, gas and arc equipment. *Air Reduction Sales*

266. Welding Equipment
Catalog on Cadweld process and arc-welding accessories. *Erico Products*

267. Welding Stainless
New 48-page booklet describes various electrodes used on stainless steel. General description of welding process. *McKay*

268. Wire and Ribbon
New 12-page booklet describes manufacture of fine wire and ribbon, wire and ribbon parts and small parts plating. *Sylvania Electric, Parts Div.*

269. Wire Belts
Folder on control mechanism for use with woven wire belts. *Knapp Mills, Inc., Guidler Div.*

270. Wire Mesh Belts
130-page manual on conveyor design, belt specifications, metallurgical data. *Cambridge Wire Cloth*

July, 1955

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When the Chips Are Down...

You Can Bet on SHARON to take the Gambling out of your STAINLESS STEEL Requirements

Type 430 Stainless and Galvanite* Coated booklets are available from any Sharon office.

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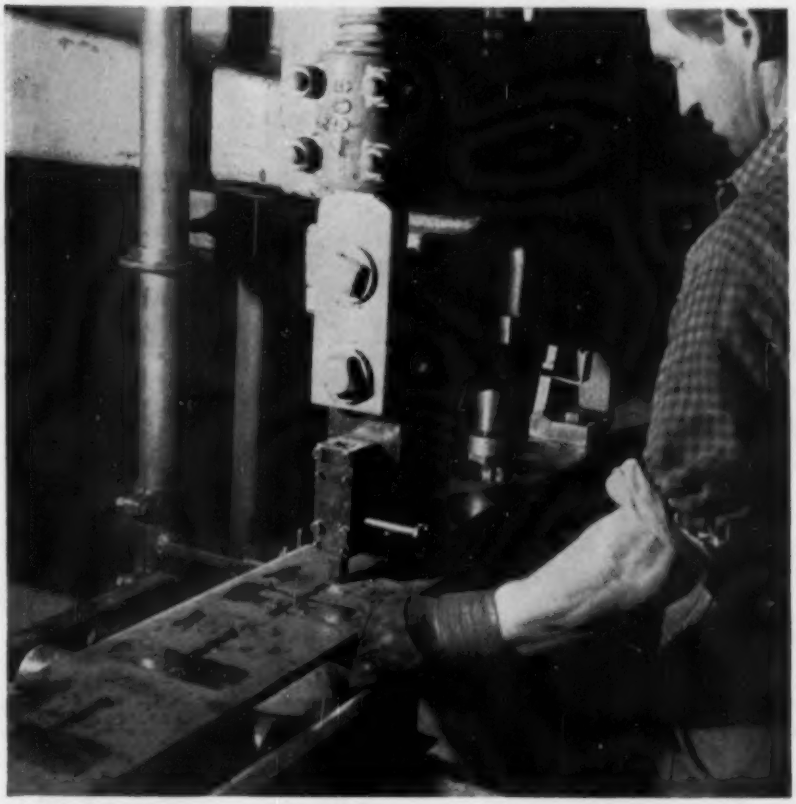
Tool Steel Topics

BETHLEHEM STEEL

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation — BETHLEHEM STEEL COMPANY, BETHLEHEM, PA. — Export Distributor: Bethlehem Steel Export Corporation



This Bearcat punch (shown above man's wrist) punches 15 square holes in each ½-in. steel plate, used as cutting edge of snow plows. Average life of punch is 5500 holes, with only three light redressings.

See What They Gained by Switching to Bearcat!

One of the operations performed in the shops of Frink Sno-Plows, Inc., Clayton, N. Y., is punching 15 holes, 11/16 in. square, in a carbon-steel plate. The plate, ½-in. thick, is used as the cutting edge of highway snow plows. With grades of steel previously used in this punching operation, the service life of each punch varied considerably—anywhere from 300 to 1500 holes.

We felt confident that Bearcat tool steel could do better, and they agreed to give it a trial.

So Bearcat was put to work, with the punch hardened to Rockwell C56-57. Production went up immediately. Now the life of each punch is approximately 5500 holes, with only light redressing of the corners required every 1500 holes or so.

Bearcat is a tough, general-purpose air-hardening tool steel. When used in punches, its chief advantages are exceptional resistance to shock, and superior resistance to wear. Besides, Bearcat's air-hardening characteristic minimizes quenching hazards, and provides good resistance to distortion in heat-treatment.

In addition to punches, there are many other applications where Bearcat can be used to advantage: rivet sets, for example, and chisels, gripper dies, hot headers, master hobs and die-casting die inserts, to name only a few.

Why not learn for yourself how good a tool steel Bearcat really is! You can order it right now through your Bethlehem tool steel distributor. It can also be obtained from our well-stocked mill depot.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Switching Grades Won't Cure Tool Troubles

Granted that quality is of primary importance in tool steel. But there are four other factors which are also essential to the satisfactory performance of tools: (1) good design, (2) correct heat-treatment, (3) proper grinding, and (4) proper application and mechanical use of the tool.

Ordinarily a manufacturer's responsibility lies only in quality. Yet if results are unsatisfactory the user often concludes that "the steel is no good," whereas any of the other factors mentioned may be the real culprit. That is why it is so important to investigate all five of these factors. For they are like links in a chain; unless they are in reasonably good balance, trouble can be expected. When this happens, the tool and its work must be investigated thoroughly before a remedy can be suggested.

In the majority of cases, switching grades is not the answer in attempts to cure trouble with tools, for the difficulty usually lies elsewhere. Before switching grades, the user should first have a clear-cut reason for doing so, and definite objective. Otherwise, the original trouble may be intensified, rather than removed.

BETHLEHEM HOLLOW-BAR SAVES TIME IN RING-TYPE APPLICATIONS

If you work with ring dies, draw rings, or hardened bushings, you can save time by using Bethlehem Hollow-Bar Tool Steel, either in BTR (oil-hardening) or Lehigh H (high-carbon, high-chrome). Hollow-Bar is made by high-speed trepanning. By this process, hammer-forged or hot-rolled bars are cored out, and are then rough-turned on the outside. With Hollow-Bar, there's no need to wait for forged rings or discs.

To cut forging costs...

WHENEVER a customer for aluminum forgings submits a design to Kaiser Aluminum's Erie Forging Plant, our engineers study it closely to see if we can lower costs, improve the design, or both.

And time after time, this second look results in big savings for customers on dies and pieces. Here are a few typical examples...

If you are now buying aluminum forgings, let our engineers review your designs with a view to effecting savings like those illustrated here.

If you have not yet converted to aluminum forgings, why not investigate now? Our engineers will be glad to work with you to help you get a better product at lower cost.

Take advantage of Kaiser Aluminum Forging Consultation Service without delay. Contact any Kaiser Aluminum Sales Office listed in your telephone directory. Kaiser Aluminum & Chemical Sales, Inc. *General Sales Office,* Palmolive Bldg., Chicago 11, Illinois; *Executive Office,* Kaiser Bldg., Oakland 12, California.

Kaiser Aluminum

setting the pace—in growth, quality and service

Whatever your furnace needs for control—

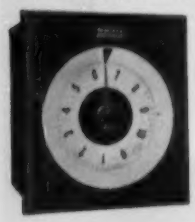
There's good reason why more heat-treating furnaces everywhere are controlled by Brown instruments. First, of course, is performance . . . sensitive, precise control that meets the most exacting requirements of modern heat-treating techniques. And equally important is versatility. In this varied line of instrumentation you'll find just about everything a furnace could possibly need in the way of control.

Choose *ElectroniK* Strip Chart Controllers for detailed, long-term records . . . and a selection of control forms including electric systems of the contact, position-proportioning (*Electr-O-Line*) and time-proportioning (*Electr-O-Pulse*) types; and pneumatic control from two-position to full proportional-plus-reset-plus-rate action.

Choose *ElectroniK* Circular Chart Controllers for ease of scale reading . . . convenient daily charts; in a full range of electric and pneumatic control forms.

Note: the basic components of all *ElectroniK* models are interchangeable . . . to simplify and speed up service.

Choose *ElectroniK* Circular Scale Controllers where you want readability and control check at extreme distance . . . without need for a record. Supplied with all contact and proportional types of electric control.



Note: all *ElectroniK* models are available in both Standard and Precision Series.

Choose *Pyr-O-Vane* Controllers where you don't need a record but do need precise vane type snap action electric control by a millivoltmeter instrument . . . also available with pulse-type time proportioning action, in both vertical and horizontal models.

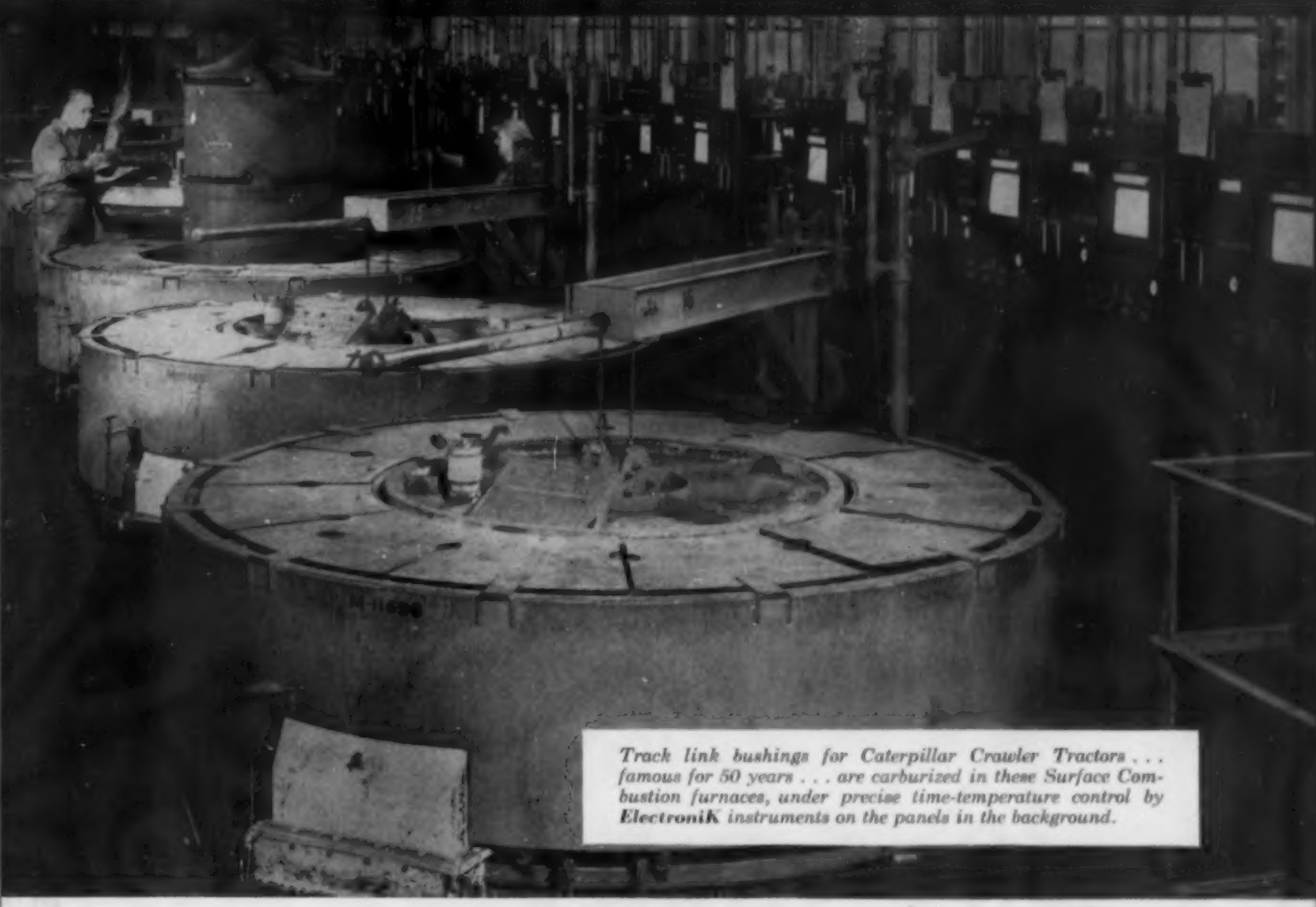
Choose *Protect-O-Vane* Controllers for simple, dependable excess temperature cut-off protection . . . can be used with any temperature control to prevent furnace shut downs and loss of production.

• • •

And for all your pyrometer supplies, investigate the convenience and economy advantages of the HSM Plan.

Flexibility for parts carburizing at Caterpillar®— in *ElectroniK*

Detailed information on all Brown instruments for regulating heat-treating equipment is contained in Catalog 54-1, "Furnace and Oven Controls" . . . complete with up-to-date prices. Write for your copy today . . . or get one from your local Honeywell sales engineer next time he calls.



Track link bushings for Caterpillar Crawler Tractors . . . famous for 50 years . . . are carburized in these Surface Combustion furnaces, under precise time-temperature control by ***ElectroniK*** *instruments on the panels in the background.*

controlled Surface pit furnaces

High quality carburizing at high production rates—this is the goal that is achieved at Caterpillar Tractor Co. Eighteen pit-type Surface Combustion furnaces carburize more than 400 tons of track link bushings every week, to strict specifications that insure long service life.

The control system for each furnace is engineered to give both the precision and the high degree of control essential to volume production. The system with *ElectroniK* Controllers regulates fuel input to the radiant-tube burners and conducts the furnaces through preset time-temperature programs. Purge, equalizing, carburizing, diffusion and cooling periods are automatically followed . . . and are readily changed when required to meet various carburizing specifications. At each change point in the cycle, signal lights inform the operator of the progress of the furnace charge.

As a safety measure, each furnace is equipped with a *Protect-O-Vane* millivoltmeter controller, which will instantly shut off fuel flow in the event of excess temperature.

The wide line of Honeywell instrumentation includes controlling, recording and protective equipment applicable to literally any kind of heat-treating furnace. For a discussion of your individual requirements, call your nearby Honeywell sales engineer . . . he's as near as your phone.

Minneapolis-Honeywell Regulator Co., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.

● **REFERENCE DATA:** Write for Catalog 1531, "*ElectroniK* Controllers," and for Catalog 54-1, "Furnace and Oven Controls."

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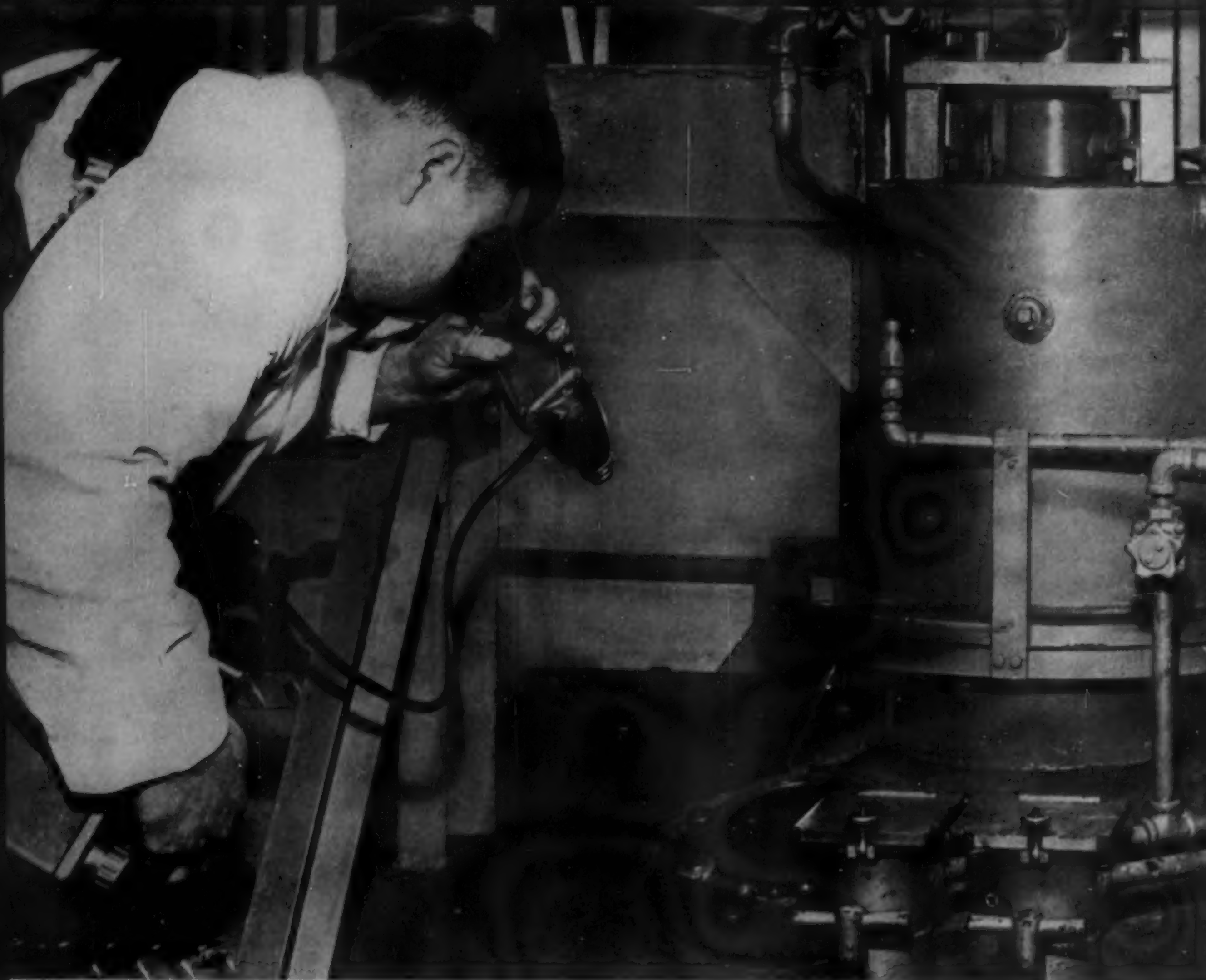
BROWN INSTRUMENTS

First in Controls

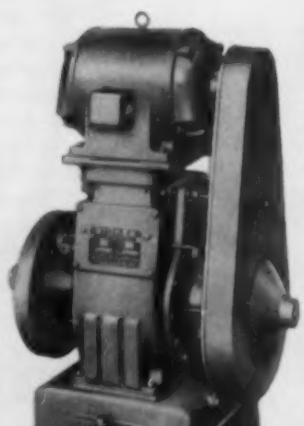


Operator at Thompson Products, Inc., Cleveland, Ohio, uses optical pyrometer to make a supplementary check on melt temperature in Stokes high-vacuum furnace.

THE COMPLETE LINE OF STOKES

Stokes manufactures a complete line of vacuum pumping equipment. This includes mechanical vacuum pumps, diffusion and booster pumps, vacuum valves and gages, and complete vacuum instrumentation. In engineered high vacuum equipment, Stokes builds vacuum metallizers, vacuum furnaces and other vacuum processing equipment.

Stokes has for many years been active in vacuum research. Vacuum experience among our engineers covers the range from laboratory equipment to some of the largest vacuum equipment in service. This experience is available to help solve your vacuum problems.

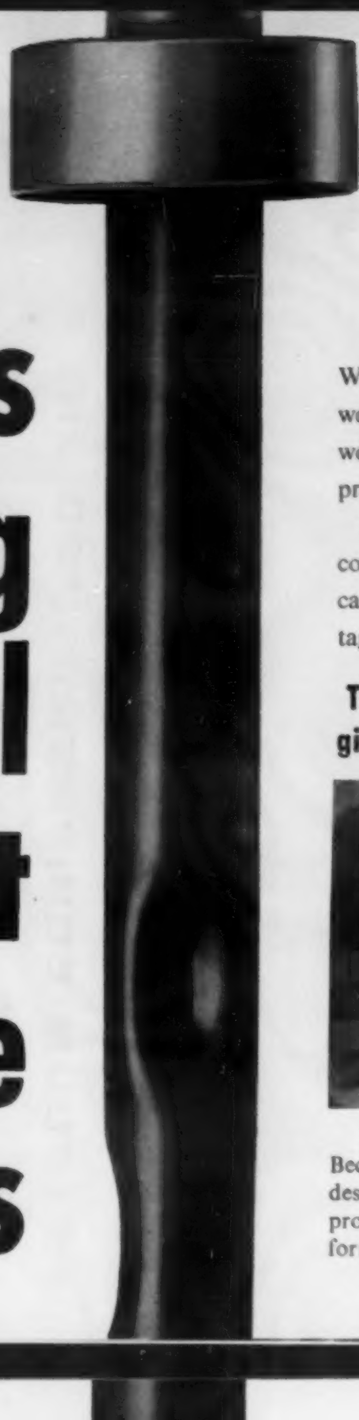


STOKES MECHANICAL VACUUM PUMPS

For vacuum processing systems and for maintaining low forepressures in high-vacuum systems, the Stokes Microvac pump provides efficient, economical operation. Designed with fully automatic lubrication and a long-lasting exhaust valve assembly, every Microvac pump is assured of smooth, trouble-free operation. Six sizes give capacities from 15 to 500 cfm. Send for catalog listed at right.

We'd like to show our vertical tube vertically. Do you mind turning the magazine?

this Lindberg Vertical Radiant Tube increases



A better way to apply heat to metal

When metal needs heat, Lindberg furnaces with the new Lindberg lightweight vertical radiant tube offer a better way to apply it. Industry the world over is finding that Lindberg furnaces with this new vertical tube provide advantages no other type of furnace can give.

Whatever type or size of furnace fits your production needs, from gigantic continuous pusher-type to the small batch-type furnace, Lindberg engineers can develop exactly the right equipment for you, embodying all the advantages of this revolutionary new vertical radiant tube.

The Lindberg vertical tube gives you these advantages

Improved Performance

Because of Lindberg's revolutionary design, this tube (patent applied for) provides a new level of furnace performance. The secret lies in the new

Typical Lindberg Vertical Tube Furnaces

Lindberg gas-fired vertical radiant tube carburizing and carbonitriding furnace. The Lindberg vertical tube is ideal for these heat treating processes which require rapid uniform heating.

furnace efficiency and lowers costs

This scale reproduction is exactly one-fourth actual size.

Lindberg tube's "dimples." Here's how they work—in the radiant tube a central stream of mixed air-and-gas is surrounded by a cylindrical stream of air alone and combustion occurs in the area between these two streams. The "dimples" create eddies in the streams accelerating combustion and maintaining even temperatures along the entire tube.

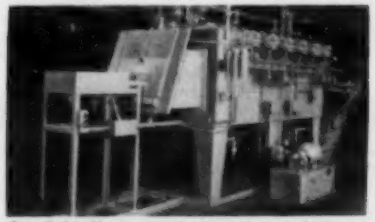
Maximum Dependability

This Lindberg tube will operate at maximum efficiency for a longer period of time. The special green silicone enamel, a Lindberg exclusive, gives greatest possible resistance to carbon penetration and greatly prolongs tube's operational life. Vertical position eliminates soot deposit inherent in horizontal tubes with resultant temperature increases at points of sooting. Lindberg tubes work effectively longer.

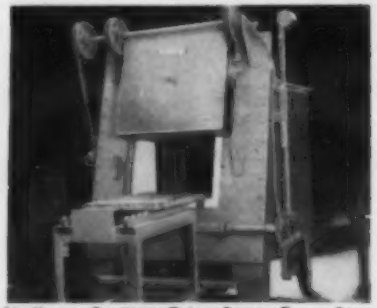
New Economy in Operation

With Lindberg vertical radiant tubes the bulk and bend problems of old-fashioned horizontal tubes are eliminated. Tubes are just 59 inches long and weigh only 29 pounds. No costly furnace shut-downs and no high labor and material cost for tube change. Turn off the furnace, lift out the old tube, put in the new one. Literally, a matter of minutes. Savings in space and fuel costs, too.

Lindberg vertical radiant tube pit carburizing furnace. Note small amount of space required for tubes.



Small Lindberg vertical radiant tube gas-fired hydraulic pusher type carburizing furnace. In this installation heating chamber is only 10 inches high.



Lindberg Radiant Tube Batch Type Box Furnace. Even small furnaces can be heated efficiently with radiant tubes.

Lindberg Field Representatives in 21 cities are ready to work with you for the improvement of your heat treating processes. Consult classified section of phone book or write us direct.

LINDBERG ENGINEERING COMPANY

2448 West Hubbard Street, Chicago 12, Illinois
Los Angeles Plant: 11937 South Regentview Avenue, at Downey, California

How Do Lightweight Refractories Cut Fuel Costs And Boost Furnace Output?

Here, certainly, is a timely question. There's a heavy squeeze today on most furnace operators for lower costs, larger production . . . or both. And despite all the economies they've put into effect so far, they're still searching hard for ways to make their furnace dollars do a bigger job.

The following discussion brings out a number of facts, often overlooked, about the money-saving, profit-building potentials inherent in *lightweight* insulating firebrick.

Q. *First of all, just what do you mean by "lightweight" insulating firebrick?*

A. Compared with dense, fireclay brick weighing approximately 7½ to 8½ pounds each, insulating firebrick range from about 3½ pounds down to slightly over 1 pound for various temperature requirements.

Q. *What does this light weight have to do with lower production costs?*

A. Briefly, heavy furnace linings waste your fuel dollars two ways:

They soak up and store large quantities of heat which are lost when the furnace is cooled; and they conduct and lose too much heat through the wall.

Lightweight insulating firebrick, on the other hand, contain millions of tiny air cells, heat up and cool quickly, absorbing and storing very little heat. Also, they resist heat flow, keeping it inside the furnace to do productive work.

Q. *I can see why you would save on fuel — but how much?*

A. There's no single answer to that question — there are too many variables to be considered. But to give you an idea of these savings, here are a few actual examples:

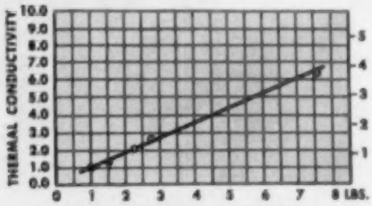
The operator of a large forge furnace cut his fuel costs more than 50% after changing to *lightweight* insulating firebrick.

A manufacturer of electric kilns states that insulating firebrick result in heat savings of fully 25%.

A magnesium melting crucible furnace that formerly used 1,000,000 BTU's per hour now does the same job with 500,000 BTU's, thanks to insulating firebrick.

Q. *Increased production has also been pointed out as an advantage of insulating firebrick. How do you explain this?*

A. Again the answer lies in lightness of weight. Because lightweight firebrick store and conduct less heat, they come up to operating temperature faster — cool down faster, too. This means — shorter heating cycles.



Relation between weight and thermal conductivity for several brands of kaolin base refractories. (mean temperature, 900F)

Secondly, because lightweight firebrick conduct far less heat than heavy, dense firebrick, you don't have to build as thick a wall. This gives you more hearth area per square foot of floor space.

Thirdly, lightweight firebrick respond more rapidly to changes in furnace heat input, which means closer temperature control and fewer rejects in many instances.

It's just like adding extra furnace capacity without adding to your furnace investment.

Q. *Are there any differences in the performance of the various brands of insulating firebrick available?*

A. Naturally, the *lighter* the brick the greater the fuel savings and furnace output. And the lightest insulating firebrick of all, for any temperature range — if you'll pardon our mentioning it — are B&W Insulating Firebrick.

THE BABCOCK & WILCOX CO.
Refractories Division
General Offices:
161 East 42nd St., New York 17, N. Y.
Works: Augusta, Ga. R-206

ONE wide-range

"OXWELD" W-45 BLOWPIPE

Trade-Mark

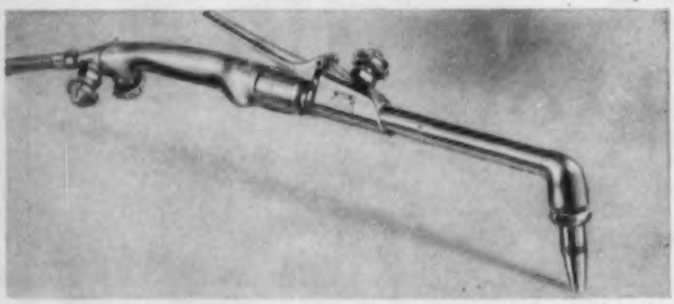
handles EVERY welding and heating job

NO OTHER SINGLE BLOWPIPE OFFERS THIS ***EXTENSIVE RANGE!***

Anyone whose daily work includes welding and heating will readily appreciate the amazing wide range and versatility of the new OXWELD W-45 Blowpipe. Its 18 head sizes (2 to 300 cu. ft. per hr. capacity) provide a perfect flame for every metal thickness. Light sheet to heavy plate, *one blowpipe does it all!*

From chrome-plated tip to offset hose connections, the W-45 shows the results of over a decade of development work by LINDE engineers. Its exclusive "jiffy-lock" heads, "form-fit" handle, and advanced styling are as modern as guided missiles and atomic power. "O" ring gas seals, flame-stabilizing mixers of improved type, and many other innovations put this blowpipe far ahead of the field in economy, ease of operation, and low-cost maintenance.

See for yourself how you can enjoy tomorrow's operating standards today with an OXWELD W-45 Blowpipe. Ask your LINDE representative for a demonstration, or write for free booklet, F-8684.



CW-45 Cutting Attachment adapts the W-45 Blowpipe for cutting steel up to 8 inches thick.

Linde Air Products Company

A Division of Union Carbide and Carbon Corporation

30 East 42nd Street UCC New York 17, N. Y.

Offices in Other Principal Cities

In Canada: LINDE AIR PRODUCTS COMPANY
Division of Union Carbide Canada Limited, Toronto
(formerly Dominion Oxygen Company)

Linde
Trade-Mark

Rush Stamping Company gives stamp of approval to Cities Service

Some of Rush's Stampings awaiting shipment. The rapidly growing, 4½ year old firm makes parts for auto hot water heaters, brake levers, vacuum cleaners, and air conditioning units.

Chief Engineer Fred W. Selter switched to Cities Service drawing oil a year ago. He praises it for eliminating need for many compounds, preventing build-up on dies, and lowering costs.

Praises Cities Service drawing oil as timesaver, worksaver, moneysaver.

The four and a half year old Rush Stamping Company of Toledo, Ohio, has already grown into a sizeable operation. Producing stampings for air conditioning units, vacuum cleaners and automotive parts, the company utilizes 41 punch presses ranging from 35 to 400 tons in pressure.

Like many other stamping companies, Rush was using a variety of paste type compounds for its drawing operations and suffering the penalty of heavy costs and build-up on dies which such compounds inflict. Then, a year ago, they switched to Cities Service drawing oil.

Here are the results in the words of F. W. Selter, Chief Engineer: "Now one Cities Service Oil does our variety of jobs, completely eliminating previous number of products and compounds required. This oil prevents build-up on dies formerly created by our paste type compounds, and in some applications saves as much as 50% in costs over these compounds. In addition, Cities Service has eliminated supply problems by offering us local warehousing and engineering services."

Learn more about Cities Service drawing oils which have already received the stamp of approval from so many firms. Talk with a Cities Service Lubrication Engineer. Or write: Cities Service Oil Company, Sixty Wall Tower, New York 5, N. Y.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS

X

This is the tenth of a series of advertisements dealing with basic facts about alloy steels. Though much of the information is elementary, we believe it will be of interest to many in this field, including men of broad experience who may find it useful to review fundamentals from time to time.

Chromium and Its Effects in Alloy Steels

As previously pointed out in this series, the elements that together make up an alloy steel work both singly and collectively. In a sense they are like the components of a machine, each having its job to do, yet each working with other components to achieve an overall result.

An earlier discussion was devoted to the functions of nickel. In this one we shall outline briefly some of the purposes of chromium, another of the fundamental alloying elements.

Chromium is a versatile agent. Among other things, it fosters depth-hardenability, improves surface resistance to abrasion and wear, and promotes carburization. Of the common alloying elements, chromium ranks near the top in hardenability. This property tends to make high-chromium steels relatively air-hardening; hence it is valuable in applications where, for one reason or another, liquid quenches are undesirable.

Chromium steels are relatively stable at high temperatures and are often used where resistance to heat is important. Moreover, the presence of chromium is a vital factor in helping to retard or prevent corrosion.

The uses of chromium steels are many and varied. Among the more familiar items that often contain chromium are hand tools, gears, springs, turbine wheels, ball and roller bearings, forged shafts and rotors, etc. There are of course numerous others; virtually no list would be all-inclusive.

One of the most useful of the alloys, chromium has been the subject of long study by Bethlehem metallurgists. These technicians have a thorough working knowledge of its effects in various types of analyses. Whenever you have a problem involving chromium steels, or would like to know more about the subject in general, by all means communicate with the Bethlehem staff. Our men will come to your office or plant at any time. You will find them co-operative and helpful.

And please remember, too, that Bethlehem makes the full line of AISI standard steels, as well as special-analysis steels and all carbon grades. Your inquiries will receive our most careful attention.

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

BETHLEHEM STEEL

Adding TITANIUM to your steel?

There's a grade of VANCORAM FERROTITANIUM to meet every steelmaking need

HIGH CARBON GRADE

Final ladle addition in rimming steel and final deoxidizer and scavenger for steel castings and fully killed steel ingots.

MEDIUM CARBON GRADE

Often preferred to the high carbon grade as a final ladle addition to very low carbon rimming or effervescing steels.

LOW CARBON GRADES

25% Titanium—carbide stabilizer in high chromium corrosion-resistant steels and deoxidizer for some casting and forging steels.

30% Titanium—carbide stabilizer in high chromium corrosion-resistant steels in applications requiring intermediate titanium content.

40% Titanium—carbide stabilizer in high chromium corrosion-resistant steels where smaller titanium additions are desired.

27-32% Titanium Special (various types)—series of alloys with high Titanium/Aluminum ratios for adding relatively large amounts of titanium to stainless and heat-resistant steels and alloys where very low aluminum content is required.

Then VANCORAM FERROTITANIUM is your best buy.

Years of experience in the production of millions of pounds of these fine ferro alloys insures the superior quality necessary for every type of product . . . from rimmed steel to the highest alloy, stainless and heat-resistant steels—and special alloys.

Contact your nearest VCA office for full details. Our Sales and Technical Service representatives will be glad to help you with your application.

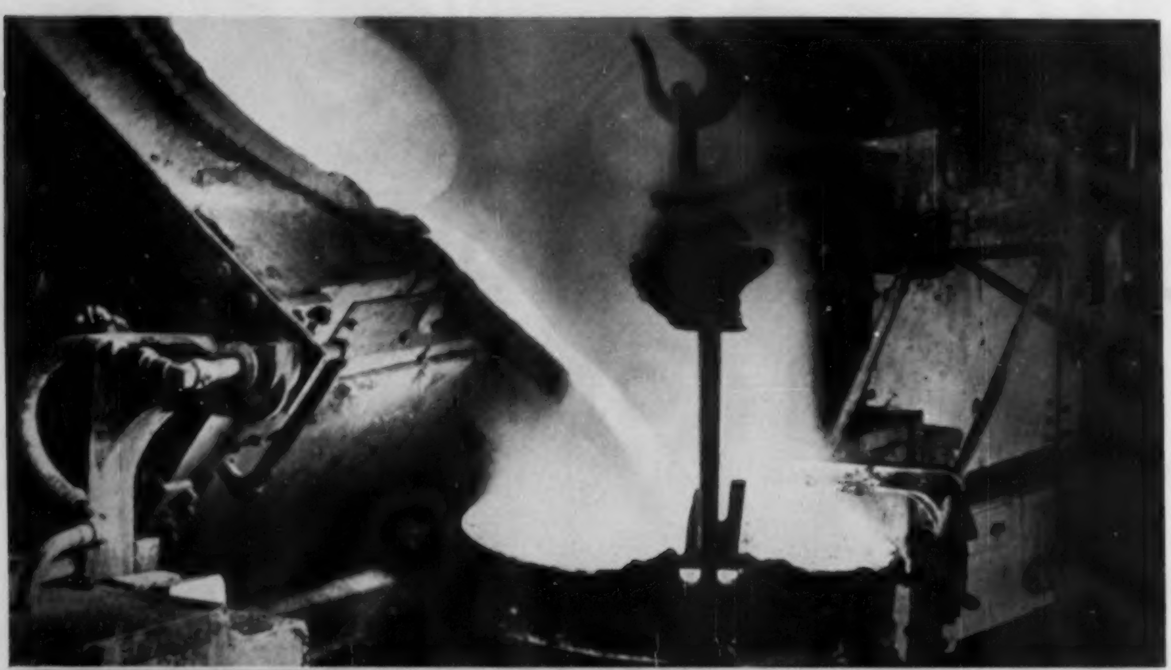
VANADIUM CORPORATION OF AMERICA

420 Lexington Avenue, New York 17, N. Y.

Detroit · Chicago · Pittsburgh · Cleveland

VANCORAM

Producers of alloys, metals and chemicals



6 tons of steel melted and poured every 2½ hours

SPEED . . . CONTROLLED QUALITY . . . ECONOMY—these advantages are enjoyed on every melt, ferrous or non-ferrous, in Ajax-Northrup induction furnaces. This furnace for example, turns out a six-ton charge of nickel alloy—precisely alloyed and virtually free of impurities—every 2½ hours.

Ajax induction melting puts substantially all the heat in the charge proper. No power is wasted in superheating crucible or refractory, and little heat escapes into the room. Speed of melting and electromagnetic stirring insure perfect alloys every time.

Ajax has been building induction furnaces for all metals since 1916. Installations capable of producing up to 20,000 pounds of metal per hour are in operation, and more and more foundries are switching to Ajax-Northrup melting as they discover its economy and advantages. Learn why in Bulletin 27-B, available upon request to Ajax Electrothermic Corporation, Trenton 5, New Jersey.

Associated Companies: Ajax Electric Company—Ajax Electric Furnace Co.—Ajax Engineering Corp.

AJAX NORTHRUP

SINCE 1916

INDUCTION HEATING-MELTING


MEDART
CONTINENTAL
MEDART

UNICHROME
Trade Mark

News about

COATINGS for METALS

Metallic . . . . Organic . . . . Decorative . . . . Protective

Improvements in applying plastisol coatings

Plating processes matched for better finishing

The first matched set of plating processes for a copper-bright nickel-chromium plate now exists to help engineers reduce finishing expense. Three integrated Unichrome processes work outstandingly well together, each deposit contributing to the end result—an outstanding chromium finish.

Equally important are the extra advantages of the individual processes. For example:

Smoother Copper

Special addition agents for Unichrome Pyrophosphate Copper Solution permit matching the deposit to the requirements exactly. With one agent, a lustrous deposit is produced which can eliminate buffing. With another, a satin finish ideal for buffing is produced—permitting buffing of the free-flowing copper rather than the base metal or subsequent nickel plate.

Improved Nickel

Deposits from Unichrome Bright Nickel prove unusually receptive to the subsequent chromium. Having low internal stress, the deposits resist cracking, and give excellent corrosion protection to the base metal. The remarkably stable solution has also reduced operating problems.

More Efficient Chromium

Wider bright plating range and higher efficiency of Unichrome SRHS Chromium Solutions deliver many benefits. Capacity of existing equipment goes up, plating time is often cut more than half, more intricate parts can be successfully covered, and users often report finishes with better "color".

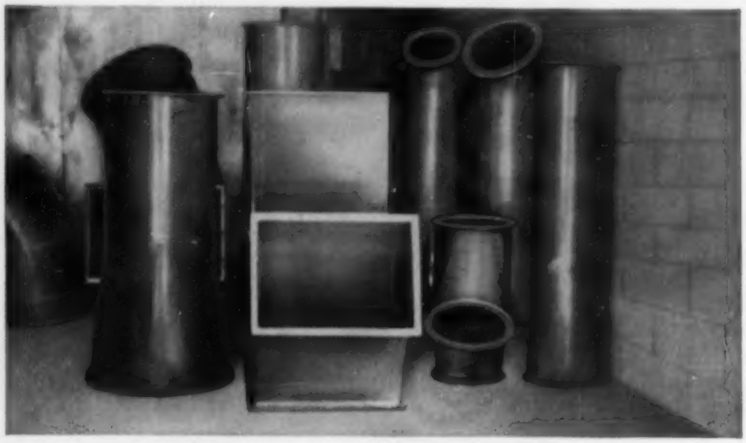
Contact the nearest office of United Chromium for details.

100 East 42nd Street, New York 17, N. Y.
Waterbury 20 Conn. • Detroit 20, Mich.
Chicago 4, Ill. • Los Angeles 13, Calif.
In Canada:
United Chromium Limited, Toronto 1, Ont.

UNITED CHROMIUM DIVISION

A Metal & Thermit Corporation

Recent developments in Unichrome vinyl plastisols permit wider use of these protective materials



Large ductwork protected with heavy duty Unichrome Plastisol Coatings. Photo courtesy Kaybar, Incorporated, Hazel Park, Mich.

PLASTISOLS are viscous, liquid compounds which are heat-cured at about 350°F. to produce attractive corrosion-resisting finishes that look and feel like rubber. Problems in applying them formerly limited their use. Now, however, two important developments by United Chromium remove big stumbling blocks.

SPRAYED-ON PLASTISOL

Ability to build up a thick coating capable of withstanding severe service is one of the greatest advantages of plastisols. Until recently, however, thick coatings could be obtained only by dip application. Now, with Coating 5300, a single coat 20 mils thick or multiple coats even thicker can be successfully sprayed to cold vertical surfaces without sagging. If products can be uniformly baked, they can now get a seamless, pore-free coating 5 to 20 times thicker than ordinary coatings. In fact, Coating 5300 can do many jobs for which sheet materials are often specified.

ECONOMICAL COLD DIP PLASTISOL

Unichrome Plastisol Compound 4129, developed particularly for wire goods, satisfies both the needs of the product designer and the production man. It provides a more economical way to produce a durable plastisol finish. 4129 can cut plastisol consumption 50 to 60%. What's more, wire products can be dipped at room temperature and production rates are substantially increased. Without waste, an abrasion resistant coating forms which gives pore-free protection against chemicals, water and other corrosives, and dosen't crack, chip or tear.

IN BRIEF

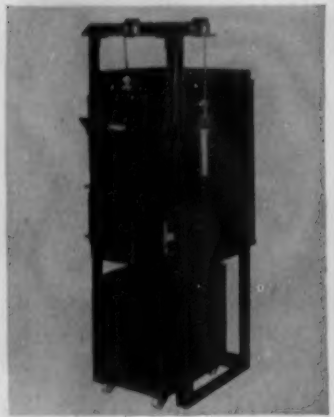
To the chemical resistance, physical toughness, dielectric strength, sound deadening and speed of curing of Unichrome Plastisols can now be added ability to be applied by almost any conventional production method. More data in Bulletin VP-1. Send for copy.

Metal Progress

Bulletin Board...

The Buyers Guide
For Metals Engineers

2 FOR 1



Series 8055

A NEW DUAL FURNACE BY LUCIFER

This series combines two independent furnaces in the same space formerly occupied by a single furnace. Each furnace is controlled independently, permitting hardening and drawing operations to be performed at one and the same time.

This type of furnace can also be supplied as a hardening and a pre-heating combination.

Four standard sizes, with special sizes to meet your requirements also available. Automatic controls are included on all furnaces. Quench tank conveniently rolls under furnace when not in use.

WRITE FOR FREE LITERATURE,
specifications and price list of Lucifer Furnaces in wide range of sizes—top loading and side loading types. Engineering advice without obligation. Write, wire or phone today.

LUCIFER FURNACES, INC.
NESHAMINY 7, PA.
Phone Osborne 5-0411

LIST NO. 122 ON INFO-COUPON PAGE 57

CIRC-AIR

HEAT TREATING FURNACES

for Every Heat Treating Process

★

CONTROLLED ATMOSPHERES

★

DIRECT FIRED

★

CIRC-AIR DRAW FURNACES

★

CIRC-AIR NICARB
(CARBONITRIDING)

Specially Engineered for Your Particular Needs

•

GAS • OIL • ELECTRIC

INDUSTRIAL HEATING EQUIPMENT COMPANY
5570 Fremont Pl. • Detroit 7, Mich.

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WELDCO

FABRICATED MONEL PICKLING EQUIPMENT

- Hairpin Hooks • Sheet Crates
- Steam Jets • Chain
- Mechanical Bar, Tube and Coil Picklers

THE YOUNGSTOWN WELDING & ENGINEERING CO.
3721 OAKWOOD AVE. YOUNGSTOWN, OHIO

LIST NO 94 ON INFO-COUPON PAGE 57

THE

Metals Handbook and 1954 Supplement

- 1532 Large pages
- 2078 Illustrations
- 1212 Tables
- 825 Articles
- 50,000 Copies in use

Order now a copy of the 1954 Supplement bound in red cloth to match your 1948 ASM Metals Handbook. The Supplement contains recent, authoritative information on these subjects:

- Carbon and Alloy Steels
- Tool Steels
- Stainless Steels
- Heat-Resisting Alloys
- Nodular Cast Iron
- Aluminum
- Copper
- Magnesium
- Titanium
- Engine Metals
- Stress Concentration
- Shot Peening
- Ferrous Castings
- Brazed Joints
- Heat Treating
- Metal Cleaning
- Press Forming
- Machining
- Powder Metallurgy
- Steel Melting
- Nondestructive Inspection
- Metallography

This handsome 200-page volume contains 24 articles supplementing the 1948 ASM Metals Handbook. Prepared by 22 ASM technical committees, it has 326 illustrations, 155 tables. It makes a worthy addition to your technical library, one you'll refer to often. For complete details of contents, see your July 15, 1954, issue of Metal Progress . . . which contains all the articles now being offered in this cloth-bound edition. Price is $4.00 to ASM members, $5.00 to non-members.

American Society for Metals, Room 789
7325 Euclid Avenue, Cleveland 3, Ohio

Rush me a Metals Handbook, the 1954 Supplement!

Name ....

Company ....

Address ....

City .... Zone .... State ....

☐ Send Metals Handbook ☐ Check enclosed
☐ Send 1954 Supplement ☐ Bill me
☐ Send both volumes ☐ Bill my Company

READERS' INFO-COUPON SERVICE, METAL PROGRESS
7301 Euclid Avenue, Cleveland 3, Ohio

Please send further information, as checked at the right, on the advertisements in the Bulletin Board with numbers I have listed below—

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(Bulletin Board Item Number)	Send Catalog or Engineering Data	Send Price Info	Nearest Source of Supply
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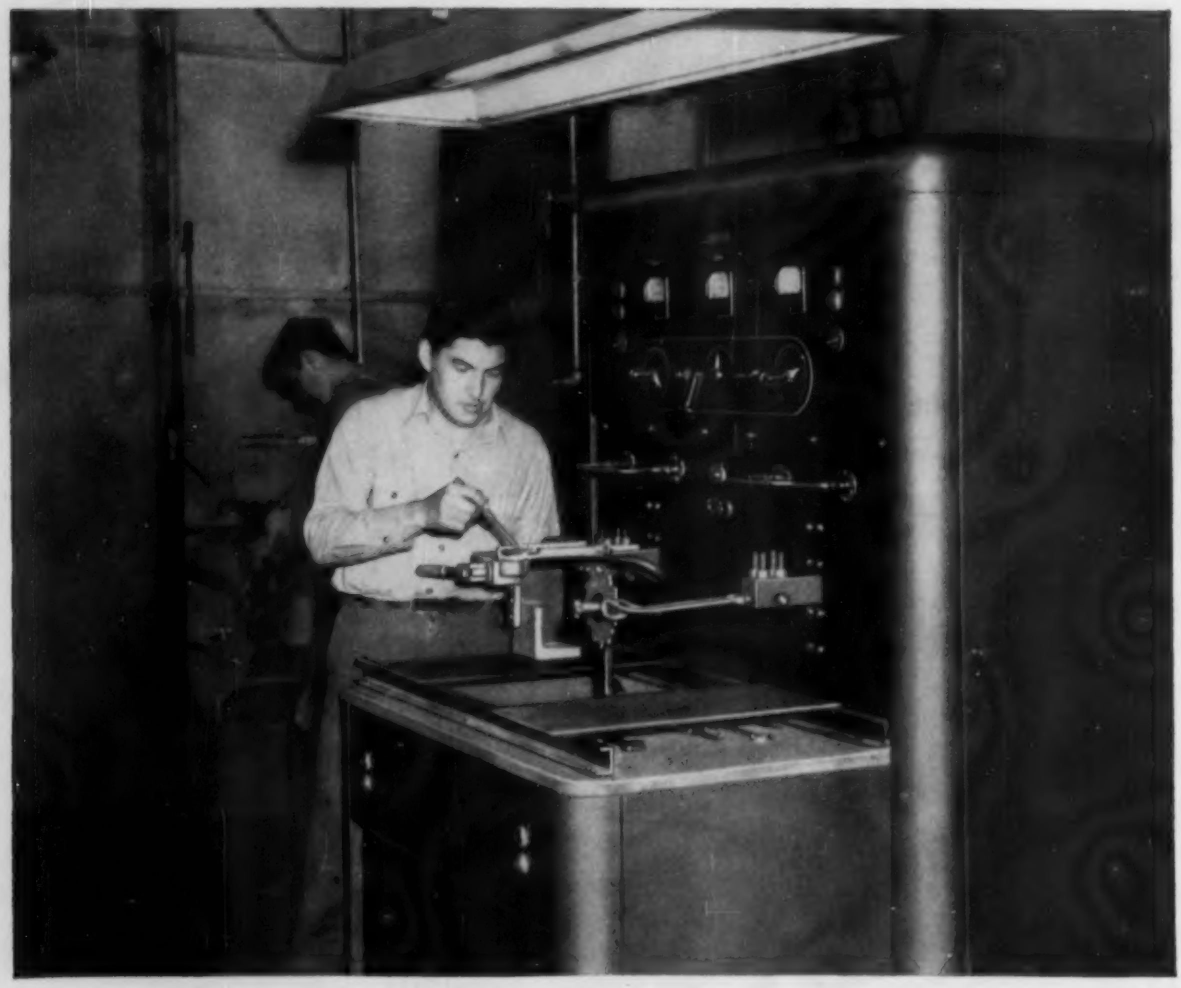


LINDBERG INDUCTION UNIT REDUCES BRAZING COSTS BY 50%

It happened in Hawthorne, California, at the Sonnet Tool and Mfg. Co., manufacturers of HELICARB Helical Carbide Cutting Tools. After installing a Lindberg 25 KW induction unit, average brazing time required for a production run of tools was tremendously reduced, resulting in substantial production economies. At the same time, product uniformity was far superior to that achieved by the previous method.

In addition to the obvious dollars and cents savings in time, labor and brazing materials, the Lindberg unit is cleaner and allows more comfortable operating conditions, according to Sonnet.

Lindberg engineers will gladly provide you with information on equipment relating to your application. See your nearest Lindberg field representative, or write for bulletin 1441.

Left to right: MERLE HILLIARD, *Vice President and General Manager;* E. C. "BUD" SUNDERMAN, *Shop Superintendent;* PAUL SAXMAN, *Chief Engineer*

Shop Superintendent, E. C. "Bud" Sunderman says: "One of the wisest investments we ever made was in our Lindberg induction unit. It has opened up new fields of carbide tooling, and has improved manufacturing procedures."

LINDBERG HIGH FREQUENCY DIVISION

Lindberg Engineering Company • 2448 West Hubbard St., Chicago 12, Illinois

Westinghouse announces . . .

New induction heater designed for easier conversion

Building-block design of the new Westinghouse 30-kw induction heater permits 32 regular combinations for your low-power applications, plus a number of special arrangements. It provides the kind of flexibility and convenience you need to keep abreast of your constantly changing production setups.

Versatile—you get custom-built installation of standardized equipment to handle a wide range of applications. Unit ideal for hardening, annealing, brazing or soldering.

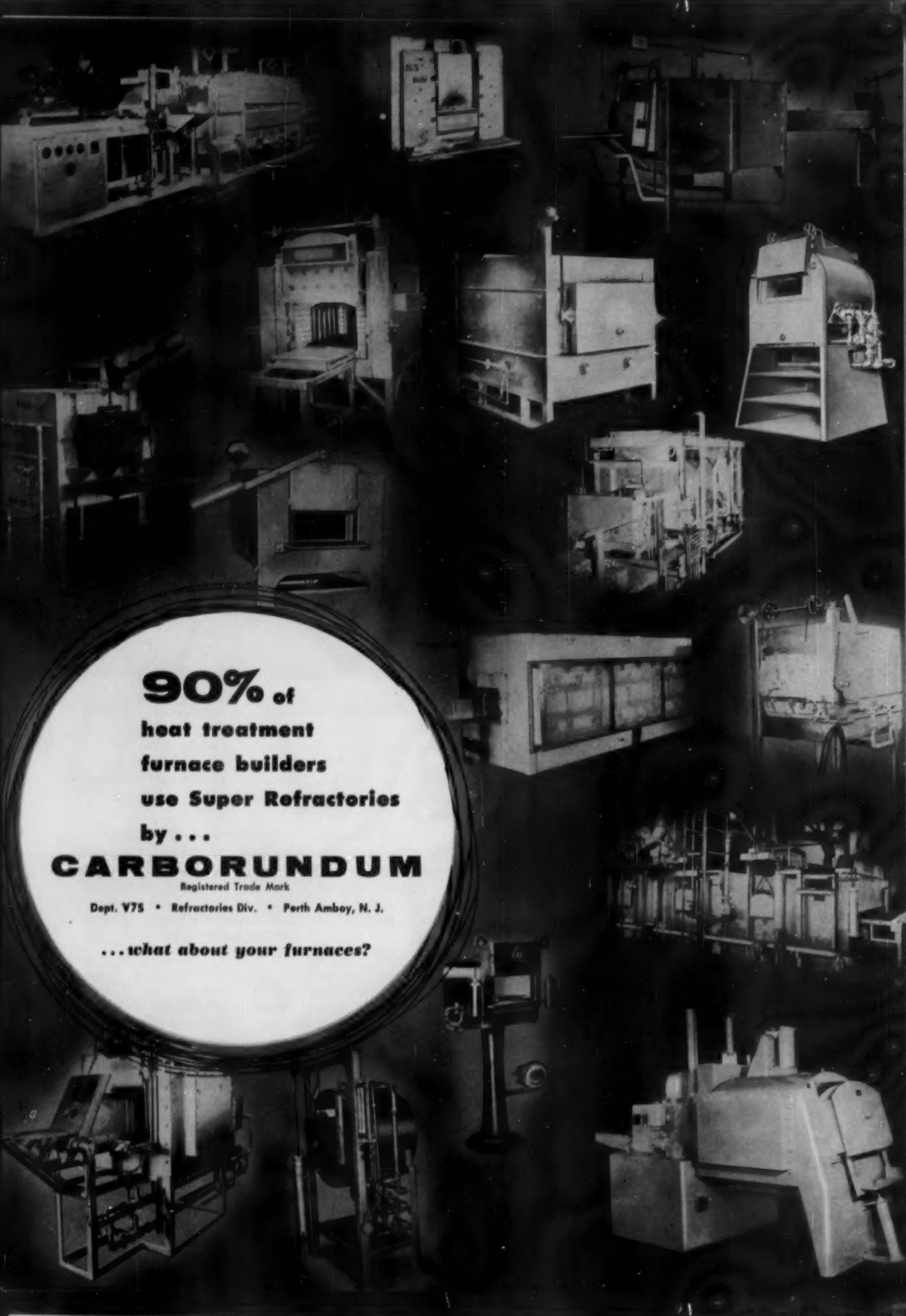
Easy to Use—front of worktable, free of controls, can be used for mounting work-handling equipment. Instruments at eye level for easy readability. M-G set readily accessible without removing panels. Buy the equipment you want, adapt it when your needs change: single to two-station operation—sink to bench top—high-voltage to low-voltage output—grouped as a compact unit to remotely located output stations.

Equipment consists of four basic units: (1) 30-kw, water-cooled, 10,000-cycle M-G set, (2) generator control cabinet, (3) high-frequency output cabinet, (4) work table.

For more information about improving your induction heating operations, call *The Man With The Facts*—your Westinghouse sales engineer. Ask him for your copy of booklet B-6519, or write Westinghouse Electric Corporation, 3 Gateway Center, Pittsburgh 30, Pa. J-02297

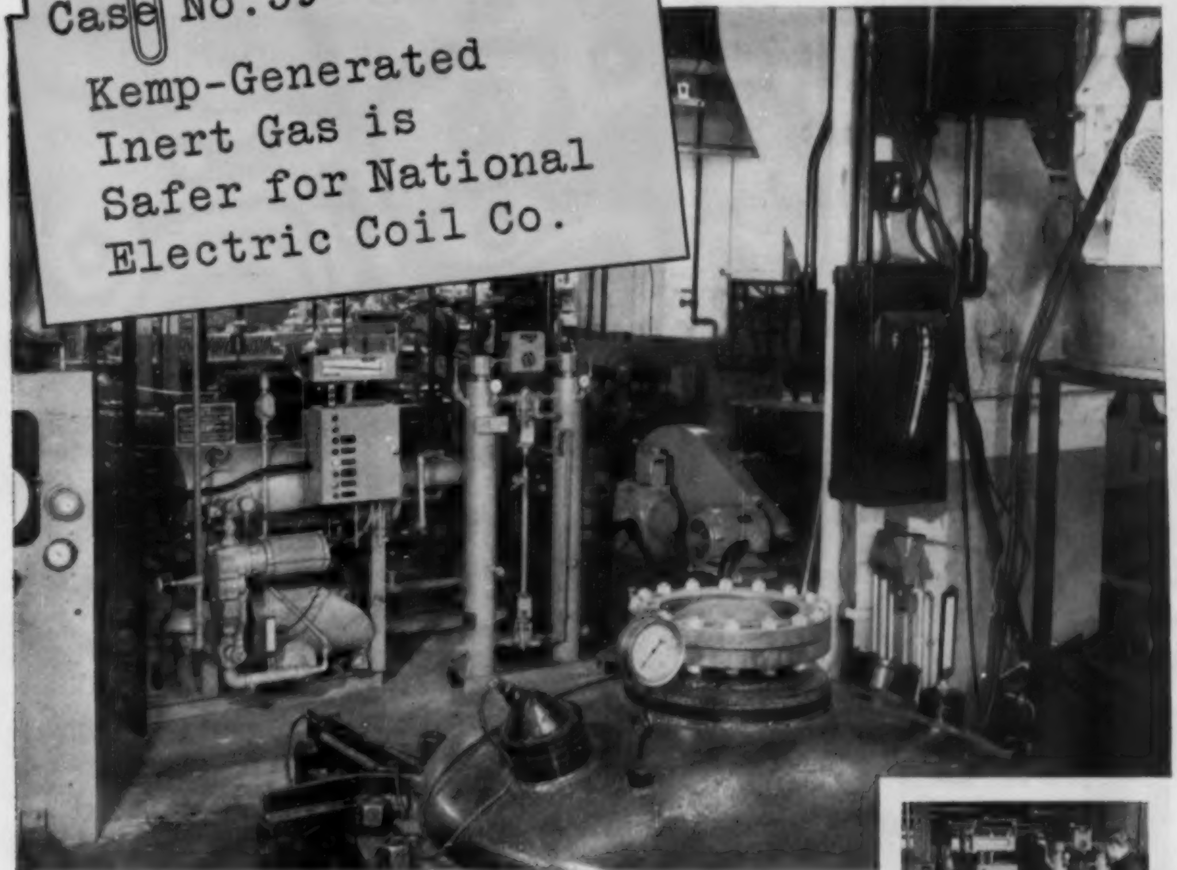
YOU CAN BE **SURE**...IF IT'S

Westinghouse


90% of
heat treatment
furnace builders
use Super Refractories
by . . .
CARBORUNDUM
Registered Trade Mark
Dept. V75 • Refractories Div. • Perth Amboy, N. J.
. . . what about your furnaces?

Case No. 59

Kemp-Generated Inert Gas is Safer for National Electric Coil Co.



How National eliminates danger of explosion . . . cheaply and conveniently

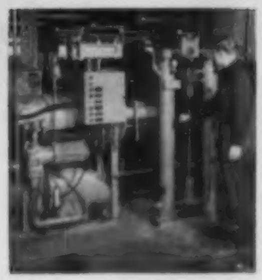
National Electric Coil Co., Columbus, Ohio, impregnates electric coils and windings by forcing in a hot sealing compound with inert gas under pressure. Formerly, the Company used air under pressure, but this created an explosion hazard. National then switched to CO_2 generated by melting dry ice. Although this decreased the danger factor, it was an extremely expensive operation and very inconvenient. To modernize this process and cut costs, National installed a Kemp Gas Generator, Model MIHE.

Kemp Solved the Problem—and More

Now National's Kemp installation delivers a completely satisfactory inert—eliminating any danger of explosion. And it delivers it at a *much lower cost* than the former generating method. In addition, Kemp supplies the gas at the rate required, plus a reserve for storage. As for convenience, the company considers their unit entirely automatic—it is practically never touched. According to Mr. D. E. Stafford, Chief Engineer, "It just sits there and operates."

Kemp Can Solve Your Problem Too

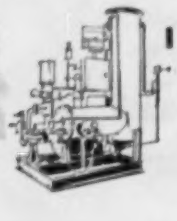
Every Kemp Generator is engineered for fast-starting, easy operation that saves both *time* and *money*. Kemp equipment delivers a chemically clean inert at a specific analysis . . . without fluctuations regardless of demand. And every Kemp design includes the latest firechecks and safety devices. For convenience, safety, and cleaner, more dependable gas—specify Kemp.



Mr. Wm. C. Graessle, of the engineering department, checking the operation. Generator features the Kemp Carburetor, part of all Kemp equipment, to deliver complete combustion . . . without waste, without tinkering.

For more complete facts and technical information, write for Bulletin I-10 to: **C. M. KEMP MFG. CO., 405 East Oliver Street, Baltimore 2, Md.**

KEMP OF BALTIMORE



INERT GAS GENERATORS

CARBURETORS • BURNERS • FIRE CHECKS
METAL MELTING UNITS • ADSORPTIVE
DRYERS • SINGEING EQUIPMENT

50-ton crane becomes 85-ton crane

with no increase in size

United States Steel's Edgar Thomson Works in Braddock, Pennsylvania, needed new and heftier crane equipment to handle larger ladles. One requirement was four new crane trolleys which were to operate on the same bridges, if possible, and in exactly the same clearances as before.

The trolleys had to be stronger but no larger than before; so ordinary steel wouldn't do. Needed, was a steel of *exceptional strength* which could be *welded easily*. Lots of alloy steels could have met the strength requirements; but USS "T-1" Steel was the *only* steel that could supply not only the required strength, but good weldability as well.

"T-1" Steel plate—in ¾" and 1" thicknesses—was used in box girders and lateral stiffener plates of the trolleys. This change increased the crane capacity from 50 to 85 tons with no increase in size.

The structure was welded with AWS E12015 electrodes. It was as easy as welding carbon steel. No stress relief was needed. And the welds developed the full yield strength of the steel: 90,000 psi. minimum.

Remember this story when you must weld very high strength parts—parts that must operate at temperatures as high as 900°F. or as low as 40°F. below zero, parts that must withstand tremendous impact abuse, abrasion or tensile stress. Then consider USS "T-1" Constructional Alloy Steel. For full particulars write: United States Steel, Room 4766, Pittsburgh 30, Pa.

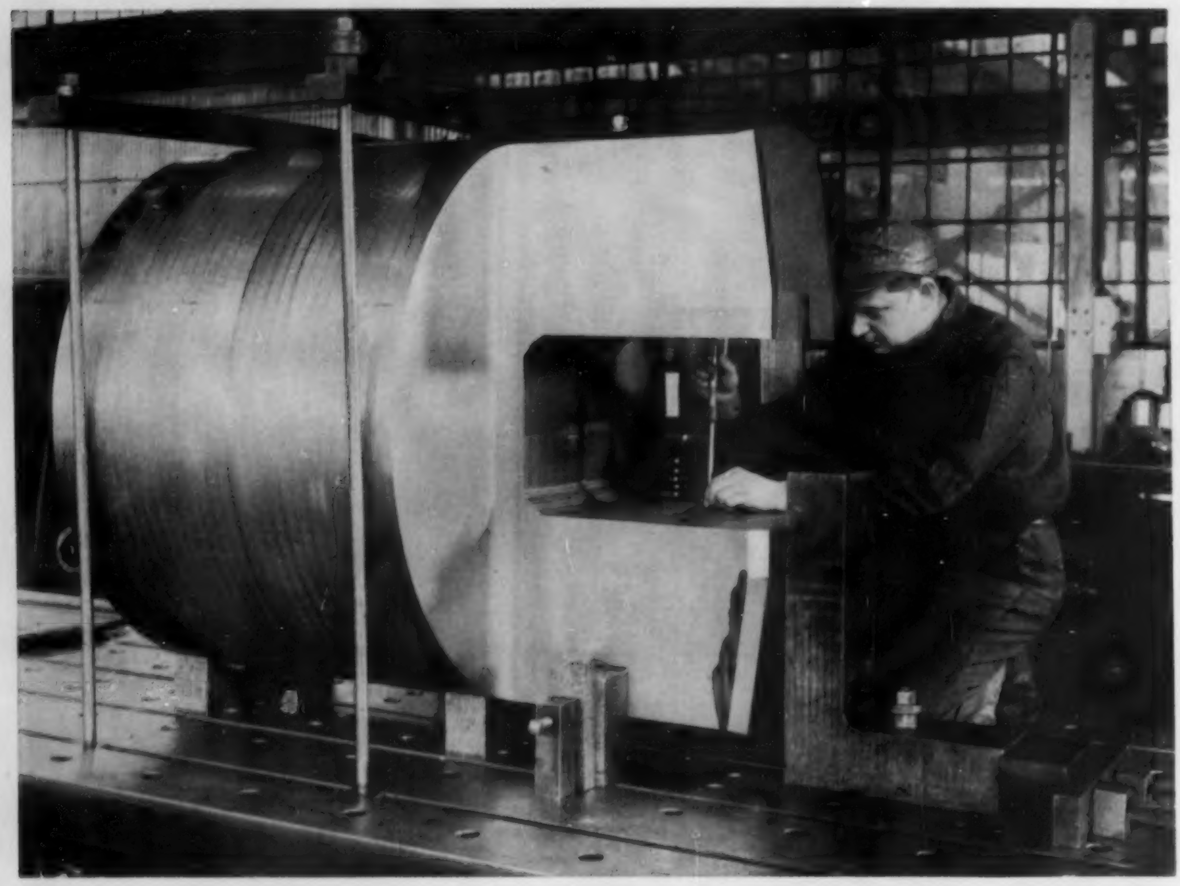
UNITED STATES STEEL CORPORATION, PITTSBURGH · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA. · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

SEE THE UNITED STATES STEEL HOUR. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

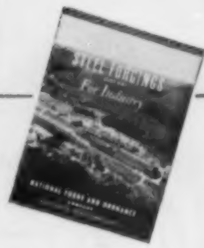
USS "T-1" CONSTRUCTIONAL ALLOY STEEL

USS

UNITED STATES STEEL



This Forging is made for really HEAVY DUTY-



Send for your free copy of National Forge's New Bulletin explaining their Operations and Facilities.

Transmitting power under constant heavy vibration and sudden severe shock loads is the future in store for this giant mill coupling. It was National Forged as a double with its mating end from a single huge ingot. It is 40-50 carbon steel treated to 72,000 Min. tensile strength with 39,000 elastic limit. This forging and its adjoining coupling are 40" in diameter x 48-1/4" long and weigh 9,800 lbs. each. They are being machined to fractional inch tolerances to keep clearances at a minimum. This care in machining is extremely important to long operational life.

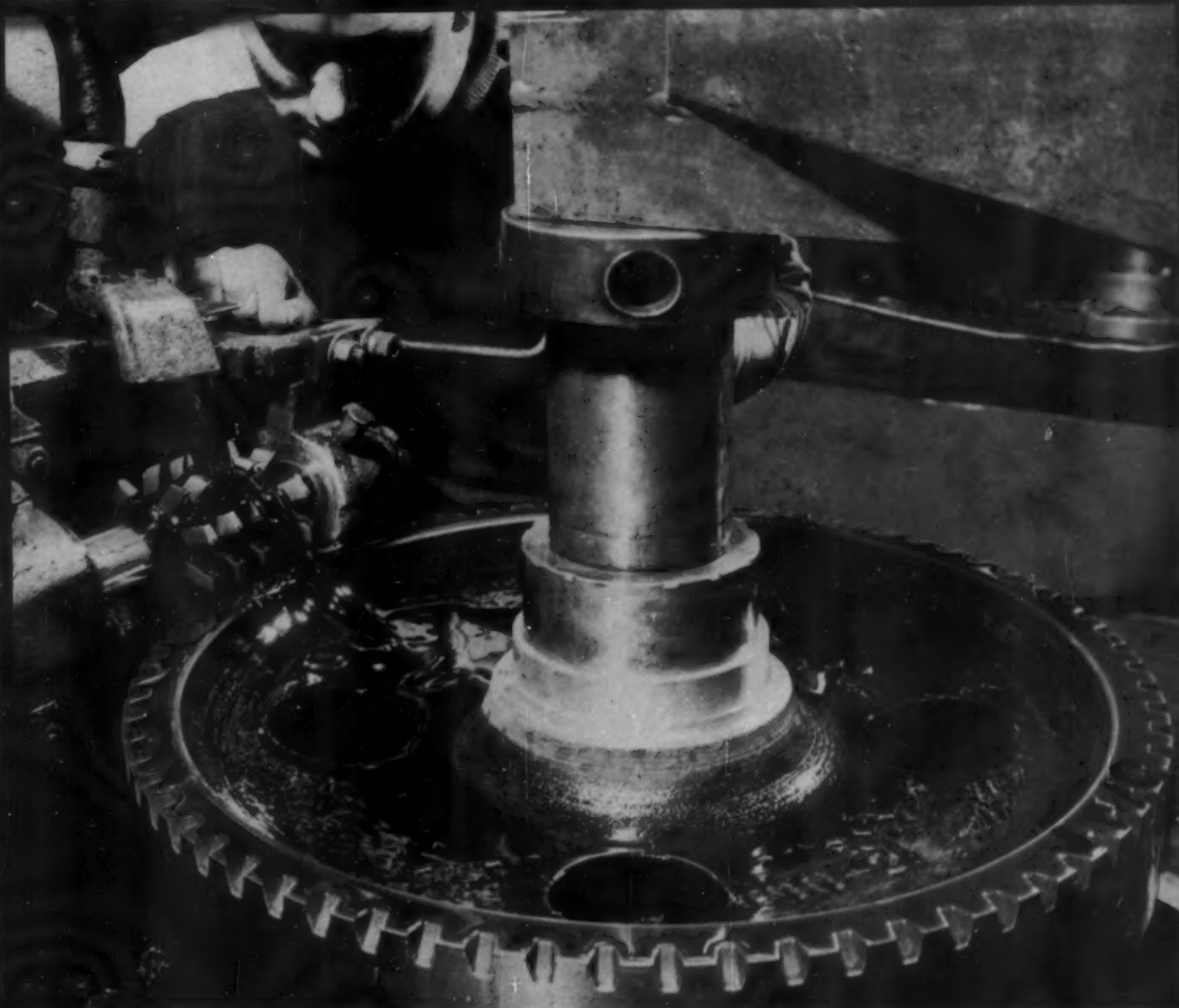
National Forge is equipped to turn out any steel to your exact analysis and finish machine to your exact specifications.

Whether your forging requirements are large or small, simple or intricate . . . try National Forge next time.

NATIONAL FORGE AND ORDNANCE COMPANY

PRODUCES BETTER STEEL FORGINGS AND MACHINE WORK

IRVINE, WARREN COUNTY, PENNSYLVANIA



Pittsburgh Gear switched to SSW forged blanks... saved 50 minutes machining time, extended cutter life 20%

Switching to SSW forged steel gear blanks in manufacturing mine locomotive drive gears has given Pittsburgh Gear Company, Neville Island, Pa. . . .

- **savings of 50 minutes in machining time.**
- **better performance through extended service life (cutter life increased 20%).**
- **reduced cutter costs.**
- **over-all lower initial cost.**

These benefits are a result of the more uniform internal structure and close dimensional tolerances of Standard Steel blanks. Machining is done on a single setup, at a maximum speed because there's no danger of hard spots and sand porosity as with castings.

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Metal Progress
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Critical Points...

BY THE EDITOR . . .

Some Observations About Aircraft

IT HAS BEEN some years since the Editor of *Metal Progress* has inspected aircraft construction on the West Coast and talked at any length with some of the multitude of keen young men who are in charge of operations and new developments. Regrettable as this may be, it does have one advantage – namely, the observer is forcibly struck with changes that might have been taken bit by bit as they came had he been a frequent visitor.

The revolution under way in all aircraft has one prime cause – the insistent demand for speed. Speed has more implications than strike the casual eye.

At the end of World War II all American combat planes were propeller driven. New structural problems as they arose were being satisfactorily solved by the use of aluminum alloy sheet. More speed was being eked out by refinements in shape, reduction of parasitic drag and more powerful engines. But there was a fast-approaching limit, not only in speed but in ceiling, both of which had already been exceeded by planes powered by the so-called jet engines. These had already seen combat service in England and Germany, and certainly were the basis of the designs then "on the boards" for future American military craft, always geared to "something better than what the Pentagon thinks an enemy might have five years from now".

At any rate for the past ten years we have had a continual stream of new aircraft of all kinds, each one surpassing its predecessor in speed, ceiling, range, armament, load-carrying ability or some combination of these. Doubtless the end is not yet. So the question naturally arises, "What are the limits of speed now available?" Perhaps the inquiry should be limited to useful speed, because it would seem that the possible speeds may be too high for any good use except in a guided missile. In fact, it is already pertinent to ask, "When does an aircraft fly so fast that a pilot can't pilot?"

Consider a fighter or an interceptor: Speeds of 1500 miles per hr. are doubtless now achieved in

Douglas "Skyrocket" — a 15,000-Lb. Aircraft Flying at 1500 Miles per Hr.

the stratosphere. Assume such a ship is approaching an enemy flying at an equal velocity toward him, and he can be seen 10 miles away. The opposing pilots would have just about 10 sec. to do something about it. By that time they would be passing each other. The time is correspondingly shortened as speeds increase, and soon (if not already) things will happen too fast for humans; perception and reaction must be electronic and mechanical. I was told we already have an airship whose pilot's function is merely to take it off and land it; in between it is remote controlled or homing. Since takeoff and landing are comparatively simple operations, it would seem that this pilot already is 200 lb. of excess baggage!

As Major Teed pointed out in his article in *Metal Progress* for March, stratospheric flight at less than 1000 miles per hr. involves properties of materials at *low* temperature, and "materials" include, among other things, those strange elements which are built into electronic devices. For the main structure, the tried and true aluminum alloys serve excellently except for those portions close to a hot engine or even hotter exhaust. At higher speeds and long flights, air friction starts heating an aluminum skin and structure dangerously. Here is where titanium alloys are supposed to take over; consequently the Editor was rather surprised to find considerable skepticism among the Southern California metallurgists. This is not unanimous, for some titanium is being used by one important organization. The consensus seems to be, though, that stainless steel of the 17 Cr, 7 Ni, precipitation hardening variety could do about everything the titanium alloys now commercially available will do and without so many headaches. In other words, the favored transition for skin metals as speeds go up seems to be aluminum to 17-7 PH to Material X. Material X is something as yet dimly defined. It will have to take over at operating temperatures of about 800° F. Maybe it will be a protected molybdenum alloy; maybe it will be porous metal cooled "transpirationally" by evaporating gas; maybe it will be a ceramic-metal combination.

(Metallic materials are not the only ones that will give trouble in an aircraft flying for some distance at Mach 3 or 4. No plastic for a transparent canopy is now known which will not soften under frictional heat at those speeds. Likewise the reader should remember that these remarks report conversations about air frames only and include no ideas from the jet engine manufacturers.)

All three of the above-mentioned possibilities for Material X, and perhaps more, are being given serious consideration. But — and this is important — a refractory skin becomes necessary only when flight is very fast and *long*. Obviously the time of flight, the useful life, of a *short*-range missile is so brief that nothing but the outer skin can get hot even at the highest imaginable speed. An epidermis could entirely burn away or melt, in fact, before the interior frame and mechanisms got hot enough to spoil electronic responses, to soften brazed joints, or to jam levers. Neither does high heat cause premature atomic explosions in the war heads.

If this reasoning is correct it would follow that the metallurgical problems in short-range missiles used for tactical purposes (ground to air, air to air, air to ground and even ground to ground) are not so much problems of a heat resisting skin as they are of light-weight materials for structure and fuel tanks, and temperature resistant materials for propulsion systems. This supposes we have adequate electronic and control devices for aiming the projectile to its target. In really long-range missiles all these problems are intensified and, in addition, a refractory epidermis and control surfaces are essential – also a reliable homing device, but I presume a generation which devised the proximity fuse can create a robot navigator which would plummet the explosive when the stars (ever shining at those altitudes) tell it that the proper latitude and longitude has been reached.

Once such devices are perfected – tomorrow, if not in fact today – what becomes of the long-range bomber? What, indeed? One can see the need for very large, very long-range airships for fast, reliable transport of men or materials to distant points, and for aerial refueling stations for faster aircraft of relatively short range. Why risk them carrying bombs over enemy territory when explosives capable of obliterating a whole city can be delivered by an expendable machine?

Of course there are many types of aircraft other than the fighter, bomber or transport so briefly considered above. It seems that many of them – reconnaissance or photographic planes, for example – need not be so very fast as long as they have fast encircling escort. Indeed, if their function depends on human reactions, they cannot be too fast. There are also many interesting developments at the opposite extreme – vertical and hovering flight, finding their best examples in the hospital or rescue ship which can land and take off almost any place on its mission of mercy. Metallurgically, however, these offer only the conventional problems of a light, strong structure and a light, powerful, reliable engine.

* * *

This brief review must be closed with some short remarks about constructional problems. Here, again, one notes the compelling influence of *speed*.

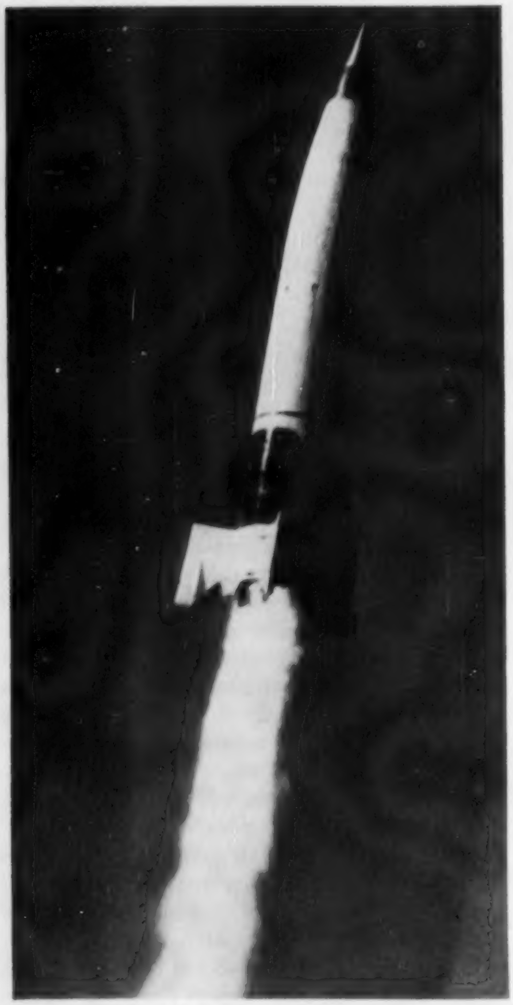
Jet engines, electronic controls, armament – all have to be packed into a minimum of space. Sometimes parts are made of stronger metal primarily to provide a few cubic inches of space for something else. If you look under the skin of some of these sleek fighters, you find an organism so complicated and close packed it almost rivals a dissected living thing.

Speed also means thin wings, maybe 4 in. at thickest element, too thin for conventional construction of sheet metal. Hence top and bottom surfaces are now milled from large slabs of heat treated aluminum alloy – say 2 in. thick by 54 in. wide by 20 ft. long. One side is skin-milled for aerodynamic smoothness (125 micro-inch finish) and for positive action in the vacuum hold-downs on the milling machine bed. Then the other side is milled to tapered thickness, leaving behind proper stiffening ribs and lugs, all to close tolerances, especially at edges and mating surfaces. Of the 3000-lb. slab, 85% may be reduced to shavings.

Such a piece must stay flat during machining. The original metal slab therefore must be as nearly stress-free as possible – a condition achieved in the mill by cold stretching the hot rolled slab about 6% to promote a fine-grained recrystallized structure during solution treating and aging, and finally cold stretching about 2% for flatness. Equalization of internal stress seems to depend greatly on speed of quenching from the solution treatment; it should be no higher than necessary to prevent incipient precipitation of the hardening particles.

After machining, the desired camber and curvature for the air foil is given in one of two ways – either by pulling it around a curved fixture and soaking it at time and temperature just short of overaging, or by skillfully shot-peening the outer (smooth) surface with very small shot (0.03 in. diameter). The latter scheme puts compressive stresses in *both* outer and inner surfaces and thus discourages stress-corrosion or fatigue in service, without roughening it enough to create sizeable drag on anything but exceedingly high-speed wings. The former gives a smoother outer surface which is in compression, due to partial spring-back from the fixture, but the inner surface in tension must be carefully protected by oxidizing and painting to resist corrosion from salt water. (The wing is also the fuel tank.)

One would think that here would be a good place for a big forging from the Air Force's extensive "heavy press program". What with the trend toward faster and faster small missiles rather than bigger and bigger aircraft, the critical observer wonders where out-sized forgings can be used. This query remained unanswered. Those who would hazard an opinion said that



The V-2 Rocket Burns 9 Tons of Fuel in 60 Sec. and Travels up to 3500 Miles per Hr.

the really big ones are "hand" forgings or "open-die" forgings; they are too rough in surface and thick in section to be used without very extensive and expensive machining. Such a forging saves much of the rough machining if you start from a block of metal, but such hogging is the quickest and cheapest part of the operation. On the other hand, this viewpoint takes no account of any improvement in grain flow and fiber disposition in the rough forged piece, as compared to the somewhat parallel macrostructure of a rolled slab, nor the fact that the huge presses with their unexampled power can make smaller closed frames or complicated pieces as closed-die forgings which can replace expensive assemblies of a dozen or more individual stress-carrying members. Such forgings are now being produced with good accuracy as to dimension and contour and even surface smoothness. Heavier presses will produce even deeper ribs and thinner webs. Likewise the aircraft engineer is learning how to work these new possibilities into his new designs, especially for parts used in sufficient quantities to warrant the cost of dies.

It would be nice if similar statements could be made about castings of aircraft quality.

The Editor was indoctrinated with welding many years ago, and so some conversation ranged on riveting versus spot welding. Much importance was put on the fact that a good spot weld requires a well-adjusted welder (both machine and man). This is not too easy to insure and even more difficult is the requirement of *clean* aluminum surfaces. Then the same question was posed as is currently being asked of glued joints and sandwich construction: "How can we inspect the spot (joint) to be sure it is strong?" (Rivets, bolts or screws can be replaced or tightened in the rare instances when they are loose – although one friend appeared to be shocked at my suggestion that tight rivets did not, to me, insure that the joint was all the designer intended it to be.) Another seasoned engineer said that laboratory tests of comparable joints in thin aluminum sheet gave better fatigue properties in riveted assemblies than in spot welded, possibly because the spot welded joint or even the complex heat-affected zone around the nugget is so rigid it introduces tri-axial stress and thus prevents those early plastic movements which are necessary to level off the peak stress concentrations and avoid overstressing at those tiny centers.

Still another metallurgist's views were more to my liking! He said that his firm had used spot welding rather extensively and had experienced no troubles from fatigue failure. In his view riveting is the favored joining method, first because there is universal experience with it, in the main satisfactory; second because prototypes are hand made (riveted); third because manufacturing methods on production models are adapted from operations on prototypes; and finally because spot welding would require fixturing and tooling somewhat too costly for the relatively few aircraft ordered from a single design. Another friend suggested that low fatigue resistance of spot welds could be corrected by heavy compression immediately after cooling, and also by redesign of joints to avoid bending at faying edges.

E.E.T.

High-Strength Steel–Aircraft Requirements

*By LEO SCHAPIRO**

The low ductility and impact strength of high-strength steel now available make it imperative that new composition or better processing methods be developed to meet aircraft requirements. (T24, ST)

Except for machining tools and forming tools, it is common practice in all metal-using industries today to use load-carrying components of machinery or equipment at strength levels under 200,000 psi. The aircraft industry has conformed with this practice, but the number of load-carrying components which must be fitted together into the total space of an airplane has finally outgrown the space available. Since the size of the components must be decreased and the service loads are not reduced, the obvious answer is to use steel heat treated to a higher strength level.

Higher yield strength and ultimate strength are achieved quite simply on several steels by using a lower tempering temperature. But does this insure a higher load-carrying capacity for the structural member? Experience is not too exact on this point. The designer is confronted with statements from many sources that higher strength levels must of necessity mean lower ductility, lower impact strength and an indefinite effect on fatigue strength. How much sacrifice must be made in other desirable properties to utilize the higher strength levels?

When the first move was made in our industry six years ago towards a strength level above 200,000 psi., a steelmaker was asked for, and did furnish, a steel of 220,000 to 240,000 psi. tensile strength with the same impact quality previously used. No moral courage was exercised by the designer since the designed material was furnished him. However, two years ago, when we asked for a strength level of 260,000 to 280,000 psi., impact strength and ductility had to be sacrificed. Some suppliers expect us to accept elongation values as low as 6% for this range of stress. A decision on this point is not easy.

Beclouding the issue is a greater emphasis on *assured* fatigue life exemplified by the term "fail-safe" design. This design philosophy cannot permit the failure of an entire airframe in the event of failure of an individual major component. This new design philosophy will require moral courage from more of us, if we do not insist on ductility, impact and fatigue qualities at the high strength level equal to those properties which have served us well at the old, low strength level. We hesitate to accept some sacrifices in ductility, impact and fatigue for the sake of using the higher strength. We shall follow those who develop new alloy steel compositions containing the proper and well-tried qualities, rather than staying with the old standby compositions which can be heat treated to give us high strength but deficient toughness. We shall follow with keen interest those who develop novel manufacturing methods which give us the desired balance of properties in any alloy.

Six per cent elongation is not acceptable if 15% is possible. Marked anisotropy is not acceptable if transverse quality nearly equal to longitudinal quality can be obtained. We already know that cadmium plating baths suitable for treating lower-strength steels without hydrogen embrittlement must be revamped to be satisfactory for high-strength steels. Our industry is a stern task master. It requires the very highest of quality and it applies its pressure to achieve this, constantly and without let-up.

*Chief Metallurgist, Douglas Aircraft Co., Santa Monica, Calif. Presented at Western Metal Congress.

High-Strength Steel–Present Limitations

*By PAUL M. MOZLEY**

Steel parts, heat treated to 260,000 to 280,000 psi. ultimate strength are now used on large aircraft at almost double the unit stresses permissible 15 years ago in similar parts of 150,000 to 170,000 ultimate. (T 24, ST)

SEVERAL years ago the American airframe industry became interested in the use of steel at higher strength levels than those previously accepted for structural or mechanical applications. Some companies became interested in special steels which were satisfactory at ultimate tensile strengths up to about 240,000 psi. Because this steel was generally available in aircraft quality and because its properties seemed attractive at still higher strengths, our work at Lockheed Aircraft Corp. was directed toward the use of 4340 steel at the 260,000 to 280,000-psi. level.

Very little was known about such factors as fatigue, notch sensitivity, ductility or the effects of variations in heat treatment, machining, plating or other processing and fabrication operations.

Our investigations began with a few fatigue tests which indicated that, contrary to popular opinion, the ratio of fatigue strength to ultimate tensile strength at the high strength level was about the same as that same ratio as determined for the conventional lower strengths. In other words, the material was proportionally higher in fatigue properties. With such encouragement, the next step was to make an actual airplane part, heat treat it to 260,000 min. and subject it to fatigue cycles approximating the service conditions of that part on an airplane. The results were so good that it was decided to start an intensive program of study in the laboratory and to also consider the actual design of landing gears using steel at the 260,000 to 280,000-psi. strength level. Detail studies were made of the redesign required for incorporation into the landing gears of our "Constellation" as well as for experimental planes being designed at that time.

*Chief Metallurgist, Lockheed Aircraft Corp., Burbank, Calif. Presented at Western Metal Congress.

Process Control for Aircraft Parts

In order to prepare correct processing control specifications, an intensified study of heat treatment and other manufacturing operations was necessary in order to insure the integrity of the fabricated parts. The details of heat treatment came first but, because of the many other processes needing close control, it was decided to put all the special requirements into one specification which has become fairly well known throughout the industry as the "Lockheed Process Bulletin 220 M".

Other factors which had to be determined were (*a*) how to machine steel at this high hardness, (*b*) whether weldments could be made by flash and pressure methods, (*c*) could parts be safely ground, (*d*) was there an increased susceptibility to hydrogen embrittlement and (*e*) could shot-peening eliminate the effects of slight decarburization. These and many other fabrication and processing problems confronted us.

It was found that better ratios between yield and ultimate strength could be obtained and produced more consistently by first normalizing at 1600° F. and then austenitizing at 1475 to 1500° F. for a somewhat longer time than is the usual commercial practice. Tempering is at 400 to 500° F., depending on the as-quenched hardness. Again, longer heat treating cycles are required to obtain consistent results than are generally used when heat treating to lower strength levels. These requirements have been

quite controversial, but tests indicate that unless the heat treatment is performed as specified the resulting properties have not been consistently satisfactory.

Machining has been quite a problem but if sturdy equipment is available the heat treated parts can be machined. High surface speeds with carbide tools are recommended and produce a satisfactory surface finish. If high speeds (about 300 to 400 surface ft. per min.) cannot be used, a very low speed seems necessary—below 40 ft. per min. It is believed that the velocity of plastic failure in compression ahead of the cutting tool is the controlling factor in determining the optimum machining conditions.

Flash welds made with the same setting used for parts to be heat treated to lower strengths would not meet the quality requirements when the alloy steel is to be heat treated to 260,000 to 280,000 psi. This necessitated closer controls and slightly different operation cycles in order to produce satisfactory welds. Pressure welds seemed to be less critical and little difficulty was encountered in determining satisfactory welding conditions.

The fear of high surface stresses caused by grinding or by straightening led to the limitation of grinding after heat treatment to those areas specified on the drawings. In addition, if any grinding or straightening is to be performed those areas must be shot-peened, both to improve fatigue and to prevent cracking during subsequent plating or cleaning.

Some of these requirements are necessary because the tempering temperatures are so low that stress relief by heating is not very effective. Some relief can be obtained after severe operations such as grinding, by heating to 375° F., but it has been considered advisable to supplement this by peening and thus avoid the possible cracking of very expensive parts.

Limitations on Cleaning and Plating

For many years it has been known that susceptibility of steel to hydrogen embrittlement is somewhat proportional to its strength. Thus, cleaning and plating processes were expected to produce severe embrittlement in steel at the new high strength. In this we were not disappointed. However the surprising thing was that certain plated specimens became ductile after baking at 375° F., while some remained brittle even after long periods of time at the same temperature. A number of processing variables seem to affect the ease with which the embrittlement can be relieved. These have been found to be (*a*) cleaning methods, (*b*) use of brighteners in the plating bath, (*c*) current intensity and (*d*) even the form of the current wave. It is suspected that the free alkalinity and temperature of the bath may also be factors.

This complex nature of the problem has led to the requirement that test specimens be placed in each load to be plated, at least until such time as it is certain that all the variables are known and controlled. At present, only the Lockheed Plant A-1 plating department and two vendors are permitted to plate any part at the high strength level. In addition, approximately double the usual baking time is specified.

Extensive tests have been performed in an attempt to determine the extent of the effects of the above-mentioned variables but so far the results are not very conclusive.

Surface Condition

Certain critical parts are required to be machined after heat treatment, in order to insure freedom from decarburization. Other parts may be heat treated without subsequent machining. In some instances the highly stressed areas will be shot-peened. Furnace atmospheres have not been dependably controlled; one part was carburized which resulted in an unsatisfactory proof test of a welded assembly. At present it appears safer to permit some decarburization and peen the part rather than risk surface carburization. Thus far it is not known how much surface carburization, resulting in a slightly harder surface, can be tolerated but we suspect that even a very slight carbon differential can be deleterious.

Since peening has been depended on for restoration of fatigue properties of decarburized parts, it was necessary to learn the comparative effect of various amounts of decarburization and the ability of peening to benefit parts of various degrees of surface decarburization. It was learned that the damage in fatigue by decarburization was about the same whether the depth be 0.003 or 0.030 in. In other words, a little decarburization is just as bad as deep decarburization in its damage to the fatigue properties of steel heat treated to a high strength level. However, shot peening is very effective in almost completely restoring the life expectancy of the parts.

Inspection was another problem which arose. How could we determine the strength of the finished part? Since separate test pieces would have little relationship to a large part, one must rely almost wholly—except for the use of hard-

ness tests on the parts themselves – on the exacting control of processing. Since the relationship between hardness and tensile strength is not a straight-line function, and since the 260,000 to 280,000-psi. strength is so close to the maximum hardness attainable in the steel, it is apparent that any relationship must be determined for each lot of steel. By tests on two heats of steel at about the highest and lowest hardness capabilities permitted by the analysis range, a near parallelogram of values was obtained and a hardness range established within whose limitations the material would have more than 260,000 psi. minimum. It is appreciated that the use of such a criterion will sometimes give us parts whose actual strength will be above the 280,000-psi. level, but this variation must be accepted as a normal expectancy. This safe range differed slightly from published hardness data and is to be considered as correct only for 4340 steel to meet aircraft specifications.

My remarks have been intended to illustrate some of the problems encountered in the use of steel, heat treated to high strengths. As I have shown, many of them have been solved, others have been partially solved and some must be studied further. We feel that great progress has been made. Only 15 years ago Lockheed was required to redesign a landing gear strut to lower the strength after heat treatment to 150,000 to 170,000 psi. because it was considered unsafe at 180,000 to 200,000 psi. The use of 260,000 to 280,000-psi. steel has thus almost doubled the load-carrying capacity of components. In the present age of increased speed and efficiency of aircraft, this saving in weight becomes very important. Perhaps even the present strengths will be exceeded by new steels, since there are several now under preliminary study for use above 300,000 psi. tensile strength. One can hardly predict what the ultimate goal may be.

We, at Lockheed, have been content with S. A. E. 4340 steel for our present applications but know full well that it is only an intermediate stage as airplane parts become larger and steels of still higher strength become available.

Titanium Fasteners

*By THOMAS F. SPOEHR**

This paper was presented at the overflow conference on "Today's Titanium Problems and Opportunities" held at the Western Metal Congress late in March and was received with such enthusiasm that an observer might decide it fairly represented the attitude of the entire audience, drawn primarily from the West Coast aircraft industry. (T7, T24, Ti)

If titanium could be used satisfactorily for all the fasteners in a large airframe, the savings in over-all weight could snow-ball to as much as 2000 lb. Aircraft designers are eager to use the weight which could be saved, but the big question is whether manufacturers are now capable of producing titanium fasteners with the necessary requirements.

After three years of cooperative development sponsored by the Bureau of Aeronautics, the fastener manufacturers can now duplicate with titanium alloys any shape to the dimensional tolerances normally specified for the more common metals and alloys. Other requirements can-

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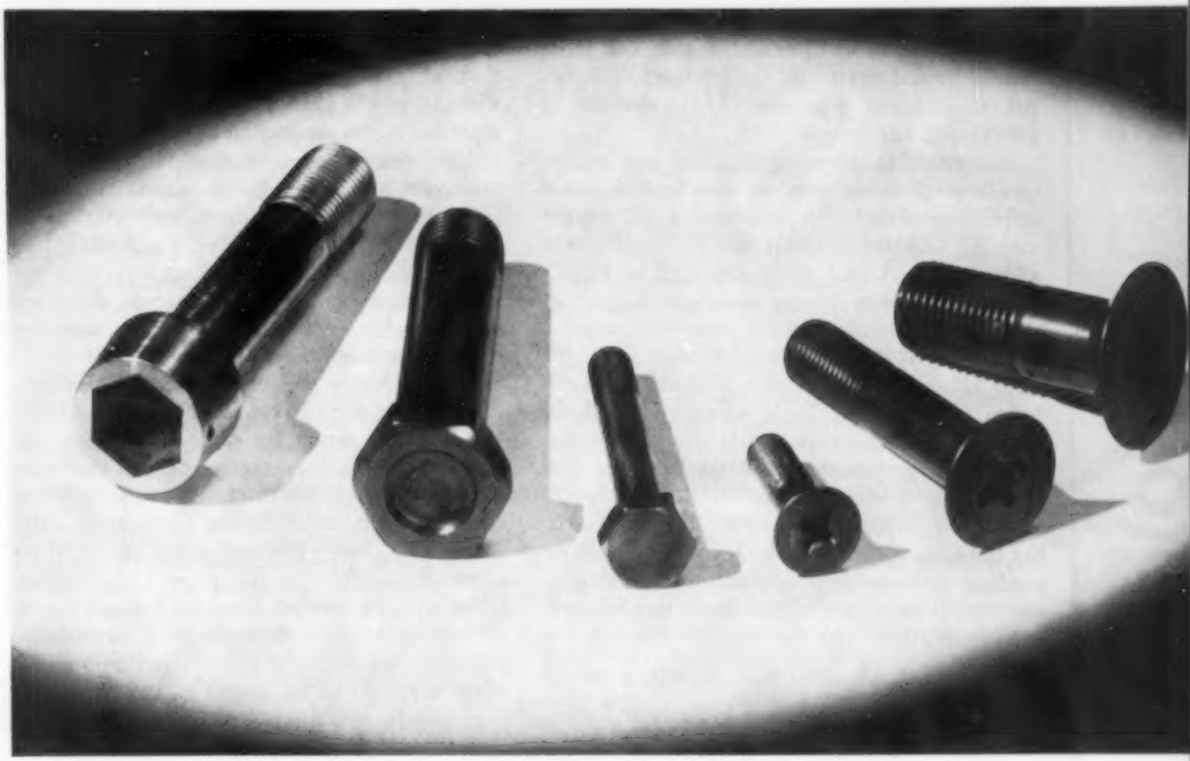


Titanium Fasteners Are Made in a Range of Sizes for Airframes

not be met as easily, and one of the biggest snags is getting the aircraft engineers to agree on what properties are most important in service. Each of the following properties has been considered of primary importance by at least one group during some period of the investigation: corrosion resistance; tensile strength; shear strength; fatigue strength; galling resistance; ductility; interstitial contamination; and surface finish. All are important and it now appears that we are getting some agreement on their relative importance and the respective values the fasteners should have.

The quality of the bar stock as received from the various manufacturers has been good – no single reject for below-specification reasons. The final physical properties of the fasteners, however, are quite another consideration and have presented some difficult problems in processing. For example, improper heat treatment at any stage would ruin the ultimate part. The answer therefore boils down, not necessarily to what you've got, but how you got there!

We have for the present standardized on 4 Mn, 4 Al alloy in the age hardened condition. The fastener is free of hydrogen or oxygen contamination. To be more specific – hydrogen content is held to less than 125 parts per million (125 ppm.). (We intend to install vacuum furnaces to be used whenever hydrogen analyses creep toward the high side of this specification.) Oxygen contamination at the surface is nonexistent. Various degrees of ductility and strength can be achieved, dependent upon what final properties are desired by the user. Tensile strengths of 150,000 to 180,000 psi. can be obtained consistently in this alloy through proper heat treatment.

Shear strengths for 4 Mn, 4 Al alloy are in the range of 95,000 to 120,000 psi. Work still remains to be done on fatigue evaluation in the higher stress levels, and preliminary results on age hardened ductile fasteners are most encouraging. This leads us to believe that within the next year interchangeability may be possible on a production basis with steel fasteners at 160,000 to 180,000-psi. tension level.

Although there are many classifications of aircraft fastenings, most of the effort to date has been concentrated on three basic categories:

(a) the 125,000 to 145,000-psi. tensile and shear type bolts and screws, *(b)* the 160,000 to 180,000-psi. tensile-shear type and *(c)* the 160,000 to 180,000-psi. tensile type.

For practical purposes the first two groups can be produced in titanium on a basis of direct interchangeability with steel and a 45% weight saving. The third group we feel still needs additional work and study although, as I have stated, the results appear most encouraging at the present time.

From what you've heard, it may sound to some of you that producing titanium fasteners today on a volume basis offers no problems whatsoever. This is certainly far from being the truth. A large percentage of the effort of our company and others in our industry has been to develop volume production techniques. It has been the forte of our industry to be able to produce items in large volume at a relatively low cost. This is one of the goals that we are striving to attain with the titanium fastener.

Economics

Volume production naturally leads to lower cost. One of the question marks that has been kicked around quite a bit has been the economics of the titanium fastener.

Suppose an airframe manufacturer is planning to switch certain fastenings in a plane *in production* from steel to titanium in order to save weight. He can figure roughly that it will cost him from \$100 to \$165 for each pound of weight saved. If these titanium parts were incorporated into the plane *at the design level,* this figure would be substantially reduced. Naturally, if one were desirous of building just one airplane with titanium fasteners, the cost would be much higher than this – perhaps two to three times as much – and this has been the basis of the more pessimistic estimates that have been circulated.

The question is quite often asked, "When is the price of the titanium fastener coming down?" I'd like to take a very realistic and honest approach to this question.

The average cost of the titanium fasteners per pound is approximately \$100. Of this \$100, the actual cost for the raw material would be about \$20. It follows, therefore, that titanium fasteners will not appreciably decrease in price as soon as the cost of bar stock edges downward. Excessively fussy manufacturing and heat treating procedures are the primary factors in the high price tag.

I would like to emphasize one point: The thing that will do more than anything else to reduce the cost of the titanium fastener will be wide-scale use in the production of airframes. To date it has been the *mañana* material; it is always tomorrow, just around the corner. Even with the best intentions, there has been very little volume production. There is, however, a prevailing feeling of optimism that before long we're going to see greater usage. When that occurs, there will be noticeable decreases in the manufacturers' costs and selling prices.

Another knotty problem confronting the titanium fastener manufacturers is that of planning. We've kept hearing for quite some time now about various large aircraft programs that were about to "jell". While this has certainly kept our hopes alive, especially since the potential size of some of these programs is very large, there is nothing definite at the present that we, as fabricators, can rely on. Because of this, it is very difficult to do much in the way of constructive planning when it involves new equipment, adaptations of existing machines, and training of personnel for this specialized type of production. Even though titanium quite often runs on the same equipment as other threaded products, most manufacturers will have to add or modify existing capital equipment to take care of this new line.

What about the future of the titanium fastener? Well, to those of us in the business who have been wrestling with this promising but temperamental little monster it has been quite a temptation to follow the old Biblical injunction: "Give no thought for the morrow; sufficient unto the day is the evil thereof." (Which translated means: "Haven't we got enough problems?")

Quite to the contrary, however, we are thinking, planning and acting on titanium for tomorrow. Our industry is convinced that it is a superlative raw material for our products and that all of the agony that is going into research and development will have been well spent.

We doubt that the mythical nail, for want of which the battle was lost, may eventually be a candidate for titanium, but we can think of few other items in the vast family of bolts, nuts, screws and rivets that may not some day be available in this wonder metal – perhaps even from stock. With this in mind we shall continue to put a maximum of time and brainpower into the titanium fastener – not only for the aircraft industry but for *all* industry.

Atomic Energy in France*

THE French government applied in 1939 for patents covering the general principles of nuclear reactors, including moderator and reflector. Six tons of uranium oxide was obtained from Belgium, and nearly 20 kg. of heavy water was brought from Norway to Paris, in spite of the war which had started. At the German invasion the uranium oxide was hidden in Morocco and the heavy water brought to England.

After the end of the war, the Commissariat à l'Energie Atomique was created. It is under the direct control of the prime minister and is almost autonomous. Regulations do not prevent quick decision or action. Employees are not civil servants.

The first task was to develop technologies, either in existing industries (production of very pure graphite for instance) or in its own establishments (production of pure uranium metal, for instance). At Chatillon, a few kilometers south of Paris, a first experimental reactor of very small power (generating about 5 kw. of heat) began operating in December 1948; it was made with sintered uranium oxide (from the prewar stockpile) and heavy water from Norway as moderator. This reactor made radioisotopes and tested purity of construction materials for future reactors. A year ago, the uranium oxide was replaced by metal rods, and the heavy water cooled externally; its power was thus raised to 150 kw.

Meanwhile a new research center was chosen on a sparsely populated plateau 20 km. south of Paris, near the hamlet of Saclay, and construction started in July 1949.

An extensive search for uranium ores located some uranium deposits of medium importance in central France, and several mines are in operation. The ore is either concentrated in local mills, or (in the case of rich pitchblende) sent directly to a central chemical plant situated at Le Bouchet, 40 km. south of Paris, where purification is done by solvent extraction, and the metal is produced by reduction of uranium fluoride by calcium. Ingots of 65 kg. are produced in each operation.

The Saclay reactor is heavy-water moderated and cooled by carbon dioxide under a pressure of 7 atm., circulated in a closed circuit by two 400-kw. blowers. The reactor is now in continuous operation at 1500 kw. (heat produced), corresponding to a maximum neutron flux of 7×10^{12} n. per sec. per sq. cm., among the highest experimental reactors in Europe (including England). The reactor is used for investigating radiation damage and for producing radioisotopes and plutonium in small quantities.

In our main research establishment, at Saclay, in addition to the general laboratories for electronics, metallurgy, and chemistry, we have three big instruments in operation: a cyclotron, a Van de Graaff accelerator, and a second more powerful research reactor.

The cyclotron has a diameter of 160 cm. (polar pieces) and weighs 300 tons. It has been designed for accelerating deuterons up to 25 Mev., but it has been used until now to accelerate heavier ions highly ionized, such as six-time ionized nitrogen atoms, which can reach energies above 100 Mev.

The Van de Graaff electrostatic accelerator can produce ion beams having a very stable energy up to 5 Mev. It is used for accurate investigations of nuclear structure or reactions, and for the production of mono-energetic fast neutron beams.

A five-year plan was formulated in 1952 to construct pilot reactors for power production, either using natural uranium or a concentrated nuclear fuel. For this second type of reactor we decided to limit our effort to the production of plutonium, which should lead to the only true bleeding process with uranium. We hope to be able to avoid concentrating uranium-235 by gaseous diffusion, though we know that the use of even slightly enriched fuel would be of great significance.

To produce sufficient plutonium, two large graphite reactors are to be built in southern France. The first one will be similar to the Brookhaven reactor. Containing 100 tons of uranium and 1200 tons of graphite, it will be air cooled at atmospheric pressure; its power should be about 40 mw. of heat produced, meaning an annual production of some 12 kg. of plutonium. It should be operating at full power in the summer of 1956. A small steam power unit will recuperate some of the energy, but not enough for the blowers. The second will be cooled by compressed carbon dioxide circulating in a closed circuit containing about 100 tons of uranium; it should produce twice as much heat and 10,000 kw. of electric power.

All these plans are to prepare for extensive use of atomic energy for power production. In France we do not have enough coal and very little oil. We will have equipped all our main rivers for hydroelectric power some 12 years from now. We think that it will then be possible to obtain a less expensive power with atomic energy as a source of heat than with imported coal or oil.

To take full advantage of atomic energy we shall have to use both primary reactors using natural or slightly enriched uranium and secondary breeder reactors (fast neutron plutonium reactors). It is only in a more distant future that this second type of reactor will predominate or may be replaced by slow neutron breeders using thorium and uranium-233. We have considered this last possibility very seriously since the discovery of large deposits of thorium ores in Madagascar.

*Extracts from a paper By Francois Perrin, director of the French Atomic Energy Commission, before the National Industrial Conference Board, meeting in New York City on Oct. 13, 1954.

Biographical Appreciation

Oliver B. J. Fraser

Assistant Manager, Development and Research
International Nickel Co., Inc.

Overlooking the East River, near the heart of New York's financial district on famous Wall Street, is the office of O. B. J. Fraser. Instead of the ticker tape and stock quotation charts native to the district, Mr. Fraser's office is decorated with portraits of metallurgical "greats", certificates and commendations from professional societies, and piles of files that seem to have something to do with nickel and corrosion. As indeed they do, for this is the International Nickel Co., Inc., where he is assistant manager of the Development and Research Division.

Born in Brockville, Ont., in 1895, Mr. Fraser arrived at a metallurgical career through the lure of the North Country. When he entered Queens University in Kingston, 17-year-old Oliver Fraser decided to get ready for a job in the silver and cobalt mines by becoming a mining engineer. A friend convinced him he ought to switch to metallurgy, and in 1916 he received his B.S. degree in metallurgical engineering. This was during World War I, and after a few months in the Canadian Field Artillery he was given a civilian job of explosives inspector by the Imperial Ministry of Munitions.

In the summer of 1917 he joined the International Nickel Co. staff at the Bayonne, N.J., plant as a metallurgical engineer. Nine months later he was transferred to the Canadian Port Colborne nickel refinery, where he became works superintendent on the night shift and subsequently research engineer. The nickel industry had hit a low ebb during the postwar depression in 1922. Nevertheless, young Fraser had already shown such talent that this year proved to be the turning point in his career. He was appointed by Inco to be senior fellow on its research fellowship at the Mellon Institute in Pittsburgh, where he conducted fundamental studies of corrosion in connection with the development of markets for Monel and other nickel alloys.

In 1924, "O. B. J.", as he became known to his associates, was brought back to Bayonne as manager of Inco's new central research laboratory. Much pioneering work was done in the early days of the laboratory. Research for the dairy industry, in which he took an active personal part, ultimately led to the development of the high-nickel corrosion resistant alloy called Inconel. Fraser also had a large part in laying the foundations for the company's famed corrosion testing program.

After nine years in Bayonne Fraser was transferred to the general office in New York to supervise the promotion of nickel alloys in oil refineries and production units. So successful was this work that in the following year he was made director of technical service on mill products, where he could follow the research developments he had seen in the laboratory into their ultimate applications in the field. His experience here was wide, and included mechanical and metallurgical engineering, welding, plating and corrosion studies. In 1947 he was made assistant manager of the Development and Research Division.

These various fields of engineering gave rein to Fraser's versatility – recognition, as well. In 1951, for example, he was awarded the Samuel Wylie Miller Memorial Medal by the American Welding Society for his studies of field applications and his promotion of welding research. It was during these years that Fraser came to the conclusion that "if you can't weld a metal you can't sell it".

Numerous publications by O. B. J. Fraser have appeared in scientific and trade journals, and he has played an active and responsible role in a number of engineering societies in addition to A.S.M. He was a national vice-president of the American Institute of Mining and Metallurgical Engineers last year and is a past president of the American Welding Society. His work on Committee B-2 on Nonferrous Metals of the American Society for Testing Materials has been continuous and important. His elected offices include 13 years on the board of directors of the A.W.S., chairman of the New York Section of the A.I.M.E. and chairman of the New York Section of the American Chemical Society's Committee on Manpower. He is a fellow of the Chemical Institute of Canada, and also a fellow of the American Association for the Advancement of Science.

Despite his personal accomplishments, one of O. B. J.'s close associates writes that "one of his greatest accomplishments has been his encouragement of others, particularly younger men, to do outstanding work. I suspect that you will find a great deal of work that has resulted from his mind is credited to other and younger men. He is a quiet, unassuming individual who has the rare faculty of accomplishing large results with a very minimum of fuss and bother."

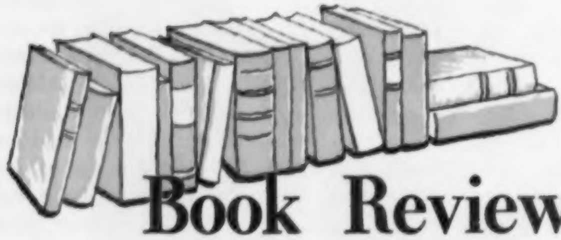
Home for Fraser and his wife, the former Effie Lefebvre, whom he married in Kingston, Ont., in 1923, is Westfield, N.J., a small residential town with a substantial population of engineers and chemists who work in nearby industrial plants and laboratories or commute to New York. He is justly proud of his son Malcolm, who is

working toward his degree of Master of Metallurgical Engineering at Rensselaer Polytechnic Institute. Malcolm's recent work showing thermal-etch-pit evidence of lattice dislocations in chromium won first prize in its class in the metallographic contest in Chicago last October and first prize for metallography in the A.S.T.M. 1954 photographic exhibit.

Although he never realized his ambition to work in the North Country (except for summer vacations during his university days), he has spent several happy vacations there fishing and boating. Another favorite summer spot is the Vermont side of cool Lake Champlain. Minerals still intrigue him; he has collected specimens for many years and is a charter member of the New Jersey Mineralogical Society. He is a voracious and rapid reader, and always has a good, pointed story to enliven a dull technical meeting.

O. B. J. is an even-tempered man with a friendly smile and a capacity to get things done. The combination of genial manner and quiet enthusiasm for work reveals his philosophy. He has an innate ability to secure cooperation in professional circles and a great energy and devotion to committee work. His professional record is an outstanding example of what a man can accomplish in engineering groups when he inspires the cooperation of others.

HERBERT B. MICHAELSON



Book Review...

Zirconium Comes of Age

*Reviewed by A. J. KAUFFMAN, JR.**

ZIRCONIUM, by G. L. Miller, Academic Press, Inc., New York City. 382 p., $7.50.

ZIRCONIUM AND ZIRCONIUM ALLOYS, A Symposium, American Society for Metals, Cleveland. 354 p., $7.50.

WHEN the Nautilus, the world's first atomic-powered submarine, went to sea, ductile zirconium came of age. This corrosion resistant metal, with its desirable low rate of neutron absorption, is second in importance only to uranium in the reactor which powers this undersea craft. Zirconium achieved this status in a relatively few years; research resulted in the production of a few grams of this "new" metal by the fall of 1945 and, four years later, some sheet that was used in the experimental reactors. Two timely books dealing with this extraordinary metal are the subjects of this review.

Over the past five years, an ever-increasing number of technical papers has kept the metal in the scientific limelight. Presentation of the story of modern (ductile) zirconium between the covers of a book devoted entirely to this subject was the logical climax. Of the books to be reviewed, one is the work of a single author and the other a symposium.

"Zirconium," by G. L. Miller, is the second in his series on the "Metallurgy of the Rarer Metals". The author is a versatile metallurgist, now director of research of Murex, Ltd. of England, the only producer of ductile zirconium outside the United States.

The other book, "Zirconium and Zirconium

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Alloys", contains a collection of papers on the subject presented at the Eighth Western Metal Congress and Exposition sponsored by the American Society for Metals at Los Angeles in March 1953. Contributing authors include specialists from industry, research institutes, universities, and government laboratories.

In a review of two books on the same subject, one may expect to encounter comparisons. Although each is concerned with the same general topic, each serves a specific but different purpose.

Miller's book, comprehensive enough to serve as a reference text, is written with the authority of a specialist. It considers most of the facets of the vast field of metallurgy. It is much more than a review and compilation. The author is well versed on the metallurgy of zirconium (as well as many other metals); fortunately for the reader, his evaluation of the literature is based upon first-hand information gained during several visits to plants and laboratories in this country.

The book contains a collection of papers selected to cover certain important phases of zirconium metallurgy. Because of its very nature, it is not as comprehensive as the other. On the other hand, well-qualified authors report the field of their specialized interest and consequently cover their subjects in much more detail.

Both books relate an interesting story.

Superior corrosion resistance at ordinary and elevated temperatures, ductility, strength, and low absorption of thermal neutrons are the properties of modern zirconium that have made it so important to power reactors which must be operated at temperatures much higher than those used at Hanford for producing plutonium.

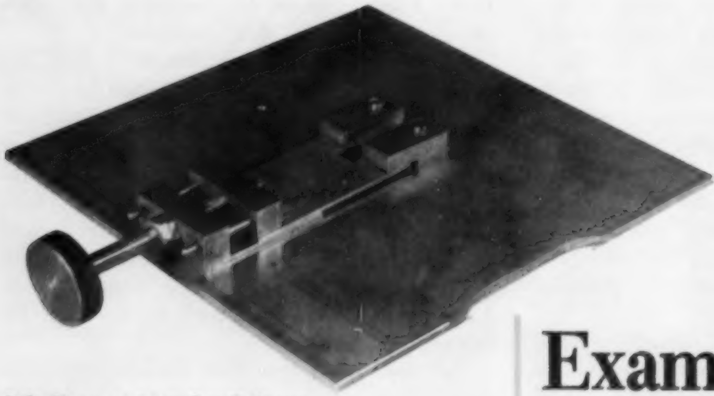
More abundant in the earth's crust than nickel, copper, lead, zinc, and other familiar metals, zirconium was once considered in the class of rare elements. Development from the hard and brittle metal separated by Berzelius in 1824 to the ductile metal known today was delayed more than 100 years principally because the various investigators did not suspect zirconium's insatiable affinity for oxygen. It was not until van Arkel, de Boer, and Fast, over 100 years later, made the compact, ductile metal by refining the impure zirconium that its many remarkable properties became known. Until zirconium became a potential structural metal for certain nuclear reactors, little progress had been made on the van Arkel process of 1925 (popularly known as the iodide process). The ductile metal was very expensive, and in small demand; eventually Foote Mineral Co. modified the iodide process for practical plant operation.

During the latter part of 1944, W. J. Kroll and his associates at the Bureau of Mines laboratory in Albany, Ore., began investigating methods for producing ductile zirconium as part of an over-all program having as its objective the application of electrical energy to the processing of minerals. Reduction of gaseous $ZrCl_4$ with molten magnesium seemed to promise relatively large quantities of high-purity metal at comparatively low cost and with no necessity for further refining.

The first intimation that modern zirconium might play an important role in harnessing atomic power came in 1948 when the Bureau of Ships wanted low-hafnium zirconium sheet in sufficient quantities for test purposes. (Hafnium is a common impurity very similar chemically and consequently hard to separate from zirconium – yet it has a high absorption coefficient for free neutrons.) This was the impetus needed to expand production facilities. Likewise, several industrial organizations investigated the possibility of producing the much-needed metal by other methods. Eventually, the Atomic Energy Commission made known its interest and since then practically all domestic production has been consigned to it. A commercial method suitable for separating the unwanted hafnium has also been developed.

At the time that demand for ductile zirconium was increasing, the Kroll process seemed to be best adaptable for the needed expansion. As a result of this successful expansion, two industrial concerns (Carborundum Metals Corp. and Murex, Ltd.) became producers. The major problem now seems to be the production of sufficient ductile metal at a price that will make its commercial utilization economically feasible. The present method is essentially a multibatch process; as such, output is limited by the number and size of the reduction units. This, of course, contributes to the high cost of the metal.

Demand from the metal-using industries will also stimulate production. It must be remembered that zirconium in its ductile form is a new metal, industrially speaking, and very few of its potential uses have been envisioned. When the requirements of government agencies have been satisfied and modern zirconium is available to industry in sufficient quantities, it is believed that the metal's corrosion resistance, ductility, and strength will qualify it for wide commercial use, especially in the chemical industry.



Side View of Microbend Tester

Examination of Microstructures Under Varying Stress

*By RICHARD A. FLINN and PAUL K. TROJAN**

A bend test apparatus is described that permits continuous microscopic examination of metal specimens while they are being loaded to fracture. (Q26, Q5, M27)

MICROCONSTITUENTS are often important in fixing the point at which metal fracture originates. Their exact role is really not known since it is usually deduced from "post mortem" examination of the microstructure. Even if the actual zone in which fracture originated is located by such an examination, it is still not as informative as continuous observation of the microstructure during deformation would be.

An obvious method of making such studies would be to prepare a thin specimen with a metallographic surface and pull it in direct tension. This was attempted but proved unsatisfactory because of internal fracture in tension as well as the inability to predict the proper area for observation as the fracture proceeded to the surface. Instead it was decided to try a bending technique so that the area of maximum stress would be known to be at the surface; also, the effect of different levels of stress could be observed at the same time by progressing from the surface of maximum tension through the neutral axis of the specimen to the surface of maximum compression.

The apparatus used for this test is shown in the halftone. The specimen, 1/16 × 1/16 × 1 in., is mounted against the fixed center support with the polished surface toward the microscope objective. Load is applied by turning the thumbscrew which moves the ends of the specimen.

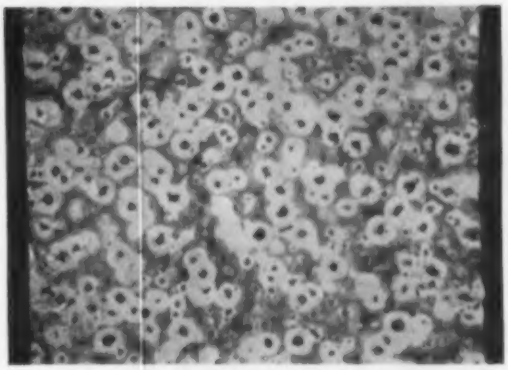
*Respectively Professor of Metallurgical Engineering and of Production Engineering, and Student, Dept. of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor.

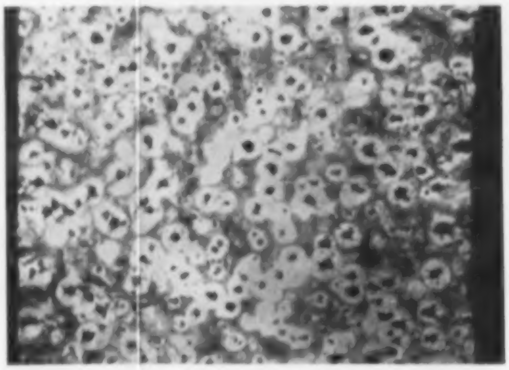
Normally the test assembly is clamped to the stage of the microscope so that the area under observation remains stationary.

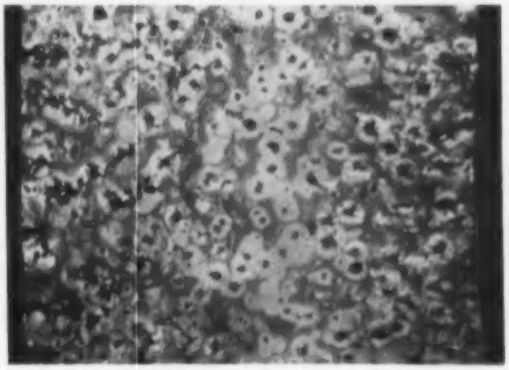
The behavior of a specimen of nodular cast iron in the microbend test is illustrated in the series of micros at the right. The white areas are ferrite surrounding graphite nodules; the matrix is pearlite. As the loading is increased, the distortion of the graphite on both the tension and compression sides of the specimen is evident. Examination at higher magnification has indicated that during the test slip takes place almost exclusively in the ferrite until fracture occurs. Then the pearlite matrix is deformed only in the path of the crack.

The progress of fracture in carburized 1020 is shown in the micros at the bottom of the page. The case is cracked at low deformation; as the bending proceeds, it opens up considerably while the ductile interior flows instead of fracturing.

When brittle materials are being studied it is often more important to concentrate on the surface of maximum tension to detect the first indication of flow and fracture. For these studies a modified microbend tester has been constructed in which the axis of loading is at 90° to the microscope stage. Further modifications are planned so that specimens can be subjected to cyclic loading for studying the initiation of fatigue cracks.

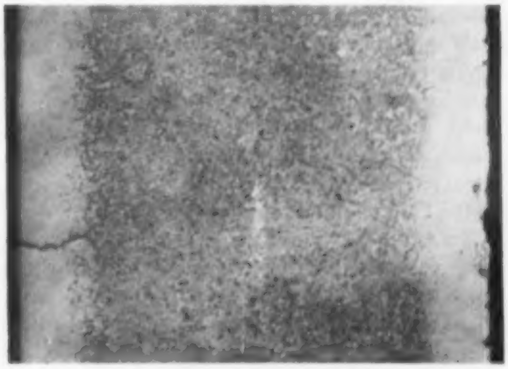


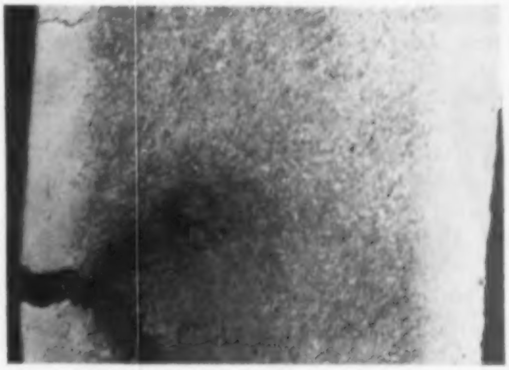


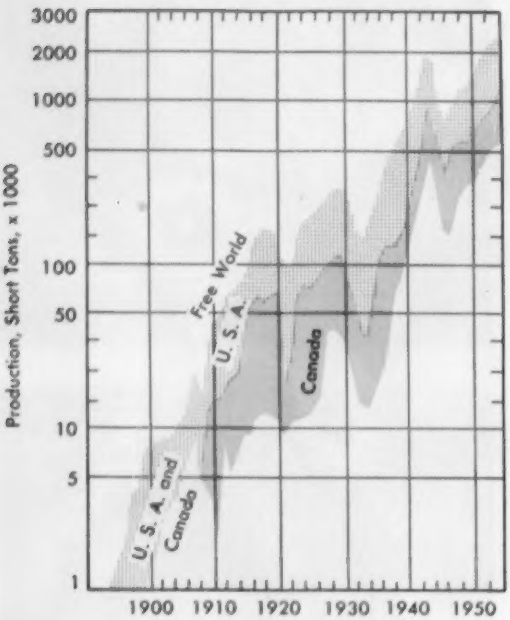


Right – Three Micros Show Nodular Cast Iron During Bend Test. Top – light load at start of test. Center – effect of intermediate load; note flow in tension and compression. Bottom – heavy load after fracture has started. 2% nital etch; 50 ×

Below, Left – Crack in Carburized Case of S.A.E. 1020 Microbend Test Sample at Light Load. Right – further bending of carburized sample opens up crack in case but ductile interior flows without fracture. 2% nital etch; 50 ×







Growth of Aluminum Production in Canada, U. S. A. and the Free World

The Canadian Aluminum Industry Today

*By I. H. JENKS**

Expansion of aluminum producing facilities in northwest Canada provides a source for future U.S.A. requirements of ingot. (B10, Al)

When the Office of Defense Mobilization of the United States announced, in August 1954, that plans for a third round of domestic aluminum expansion had been canceled, attention was focused on Canada as a supplier of primary aluminum. The Aluminum Co. of Canada Ltd. (Alcan), largest of the operating companies of Aluminium Ltd., produced about 570,000 tons of aluminum ingot in 1954. This included output from the Kitimat smelter which started operations last August. This plant, newest of Alcan's reduction facilities, has an annual capacity of 91,500 tons but can produce, after extension to its second phase, 150,000 tons and eventually, 550,000 tons. Alcan also has four aluminum smelters in the province of Quebec with hydro-electric power developments and a number of plants for beneficiation of raw materials and the manufacture of secondary products. Present ingot capacity of 638,500 tons represents approximately one-fifth of world capacity. The chart shown above traces the development of Canada's position as a producer of aluminum ingot and compares it with growth of production in the United States and the world.

To produce aluminum economically, it has been essential for the industry to locate where electrical energy can be developed at low cost. The Canadian industry had its beginnings in 1900 when the Pittsburgh Reduction Co. decided to

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Tubular Aluminum Tower on the Kemano to Kitimat Transmission Line

build an aluminum-producing plant at Shawinigan Falls, Quebec, to utilize water power then being developed on the St. Maurice River. A separate company, the Northern Aluminum Co., was formed and it became the Aluminum Co. of Canada, Ltd. in 1925.

At present the total power developed on the Saguenay River system in Quebec is 2,580,000 hp., most of which is consumed in producing aluminum ingot. This constitutes a large proportion of the power available from all installed facilities in Canada (14,929,000 hp. in 1953). The Kemano-Kitimat development in British Columbia was undertaken because of the prospects of uninterrupted hydro-electric power at an economical cost. It includes the development of hydro-electric power at Kemano, some 400 miles northwest of Vancouver, and the construction of an aluminum smelter with related facilities on tidewater at Kitimat about 50 miles away. An aluminum double circuit transmission line, the largest aluminum cable ever produced, carries

The First All-Aluminum Highway Bridge in the World at Arvida, Quebec. Shipshaw Power Development in background

Table I – Aluminum Consumption Per Capita*

Country	1937	1951	1952	1953
U.S.A.	3.55	16.3	16.57	21.29
Canada	1.9	12.2	10.52	11.37
U. K.	2.8	11.5	12.47	10.97
Sweden	1.64	7.9	8.21	8.22
Switzerland	5.30	11.9	10.82	8.19
Norway	0.75	7.8	6.7	7.33
Austria	0.30	6.69	7.03	6.56
West Germany	4.24†	5.4	5.99	6.31
Italy	1.33	2.9	3.02	3.77
Netherlands	0.5	2.6	2.92	2.60

*Virgin plus secondary plus imports of aluminum in all forms less exports of aluminum in all forms — adjusted for inventory differences when available; in pounds. †All Germany.

Table II – Industrial Use of Aluminum in Canada and U.S.A.

	Canada	U.S.A.*
Transportation (land, sea, air)	9.4%	28%
Appliances	8.6	13
Electrical and communications	35.0	11
Construction and building materials	34.0	18
Machinery (nonelectrical)	......	12
Chemicals and paint	7.6	2
Containers and packaging	2.2	4
Food and farming	2.3	....
Ferrous and nonferrous metallurgy (distinctive uses)	......	5
Miscellaneous	0.9	7

*A.S.M. Metals Handbook 1954 Supplement, p. 52.

the power to the smelter at Kitimat. It is supported from aluminum towers of tubular design over the 5300-ft. Kildula Pass.

In the reduction plant at Kitimat, the electrolytic cells in which the aluminum is produced operate at currents of up to 100,000 amp. and line voltages up to 1000 v. with a voltage drop across each cell of about 5⅜ v. The amount of electricity consumed is between 8.5 and 9.0 kw-hr. per lb. of aluminum. Consumption of carbon electrodes is about 0.6 lb. per lb. of aluminum.

Canada, itself, uses only 15% of its output of ingot. Major export markets in 1953, other than the United Kingdom and the United States, in descending order of tonnage were: Netherlands, Sweden, Australia, Brazil, Switzerland, West Germany, Italy, Mexico and South Africa. The consumption of aluminum and its alloys per capita in the free world is shown in Table I.

The use of aluminum and its alloys in Canada, by industrial categories, by comparison with use in the U.S.A. is shown in Table II.

The electrical industry in Canada has consistently led the field in the consumption of aluminum. The electrical conductivity and low weight of aluminum conductors and ACSR (aluminum cable, steel-reinforced) have resulted in heavy tonnages of these products being used for transmission and distribution lines. In

Canada, 95% of such lines are constructed in ACSR. Aluminum is also used to sheathe underground cables. Other uses in the electrical industry include substation parts and equipment, switch gear, busbar, windings for transformers, generators and rotors, service drops and domestic wiring, conduit and various components of radar, television, and transmission and receiving apparatus.

In both Canada and the United States, medium and high-strength alloys are used in structural applications where the properties of high strength combined with low weight are required. Examples include movable and fixed bridges, and various types of buildings. The world's first all-aluminum highway bridge was constructed at Arvida, Quebec, in 1950. Before it could be built, it was necessary to develop an annular head rivet and a technique for cold driving these rivets in large diameters (over ⅝ in.).

In the building trades sheet aluminum in plain and corrugated forms is used in ductwork and for roofing and siding. One form, a trapezoidal corrugated sheet, is self-supporting and is suitable for construction of smaller type dwellings, cottages, hunting lodges and storage sheds. Aluminum extrusions produced by Alcan were used as early as 1949 for wall facing panels on the 23-story Laurentien Hotel in Montreal. Other uses for extrusions in the Canadian building trades are in sections for windows, scaffolding, angles and beams, moldings, and trim.

In transportation many components of railroad cars have been built of aluminum alloys to reduce dead weight and increase payloads. The Aluminum Co. of Canada, in cooperation with the Roberval and Saguenay Railroad Co., one of its operating subsidiaries, developed and has had in service for five years an all-aluminum boxcar of riveted construction. Aluminum has also been used successfully in trucks, tankers and buses.

Among many shipbuilding applications an outstanding one has been the aluminum minesweepers and escort vessels for the Canadian Navy. The minesweepers are highly maneuverable vessels, 140 ft. long with a beam of 26 ft. They are completely aluminum except for a sheathing of wood joined to the aluminum hull. This use of aluminum alloys for the minesweepers is the most extensive ever attempted for a shipbuilding program of comparable size. Many of the vessels of Saguenay Terminals Ltd., Alcan's associated shipping company, exemplify new marine applications of aluminum. In the S.S. Sunrip, 121 tons of aluminum alloys have been built into the superstructure, funnels, davits, lifeboats and furniture. In the Canadian fishing and fish processing industry aluminum has been widely used for linings of fish holds, refrigeration units, tote boxes, and certain types of cans.

Summer Cottage Built With Self-Supporting Corrugated Aluminum Sheet

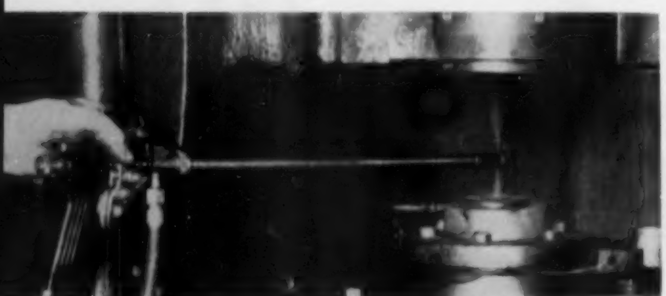
Short Runs...

Die Casting

According to a report issued by the American Die Casting Institute, the voluntary plan for quality control the Institute has sponsored is finding an increasing number of supporters from its members. The plan, called Certified Zinc Alloy Plan, requires the participants to use zinc alloys conforming to A.S.T.M. specifications for composition and to submit samples of production castings to an independent testing laboratory for chemical analysis. The participating members are authorized by the Institute to use the CZAP (Certified Zinc Alloy Plan) seal on the castings they make. Enforcement of license provisions is maintained by sampling castings for chemical composition after they have been released by the die-casting shop to the customer.

Forging Lubricants

One way of overcoming the tedious and messy job of applying lubricants to dies in brass forging operations is to use spray guns having extension nozzles that spray upper and lower dies simultaneously (see photo below). An even film of lubricant of desired thickness is easily deposited and is a cleaner method than swab application.

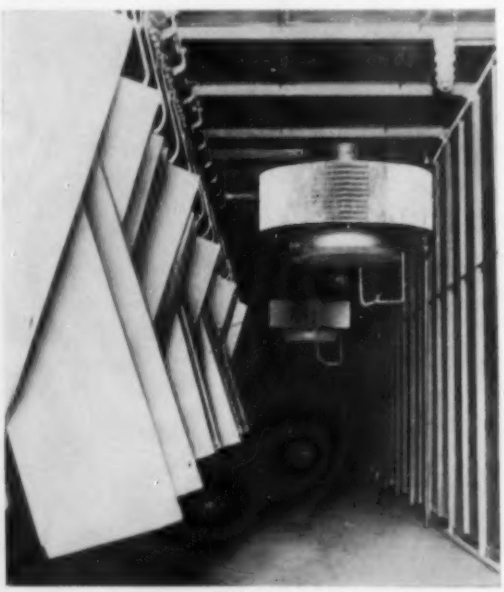


Drying Oven

The J. I. Case Co., Racine, Wis., has found that unit heaters can provide the air circulation and heat needed in a tunnel-type paint drying oven. Five of these vertical discharge heaters maintain a constant temperature of 180° F. in the oven, which is large enough to dry about 53,000 lb. of paint-sprayed parts for farm machinery every hour.

These heaters not only reduced construction cost, but they reduced power requirements and drying time almost in half. They deliver 2,750,000 Btu. per hr. and can warm the oven from room temperature to 180° F. in less than 5 min.

Five Unit Heaters Dry More Than 53,000 Lb. of Paint-Sprayed Farm Equipment Every Hour in This Drying Tunnel at J. I. Case Co. (Photo courtesy Young Radiator Co.)



Human Body Fluids Affect Stainless Steel

By CARL ANDREW ZAPFFE*

A brief account of surprising happenings to stainless steel from its contact with fluids of physiological processes. The resulting failure became a central issue in a court case. (R1, SS)

In a recent jury trial in the District Court in Washington, D. C., attention centered on an unexpected failure of Type 316 stainless steel ("18-8 S Mo") used in bone fixation. By "bone fixation", is meant the bridging of a bone fracture with a narrow metal plate that is anchored by screws driven into uninjured sections to either side of the fracture. Surgery and metallurgy have cooperated over a number of decades on the problem of selecting a proper metal or alloy for internal structural services, but the history is a consistent record of necrosis of bone and soft tissues, interference with bone growth and repair, with consequent delayed union, mal-union and nonunion of the bone. Among the metals that have been tried are silver, gold, lead, tin, aluminum, copper, iron, steel, nickel, nickel silver, bronze – these generally being rejected by the bone with accompanying pain, local swelling and discolored sterile pus.

Immediately following a fracture, the conditions of trauma involve hemorrhaging and necrosis (death of tissue) in both soft and hard parts of the bone, with inflammation following in a few hours from effects of the autolytic products

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Fig. 1 – Mechanochemical Fracture in a Collision Plate Made From Type 316 Stainless Steel. Top – Reassembled Collision; natural size. Bottom – enlarged view showing microfissures adjoining the fracture. 9 ×

of necrosis. At this stage the pH of local tissue fluids drops as low as 5.3 to 5.6 with consequent tendencies toward decalcification. Finally, these acidic fluids become dispersed by local circulation, the pH rises, favorable conditions for calcification are restored, and a fibrin network forms from the clotting of hemorrhage and exudate, the pH attaining a value near 7.35 when healing is complete.

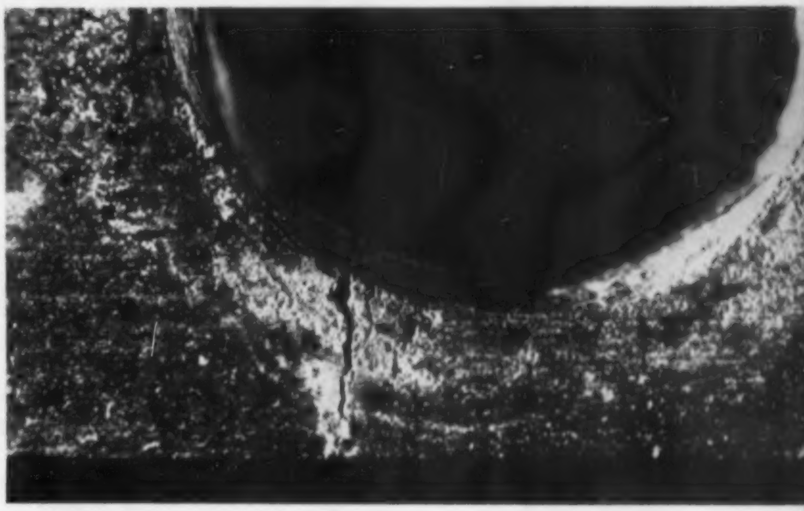
In the course of this complex body chemistry, not only are metallurgically active reagents produced, but the conditions of corrosion are characterized by a complete protection from the atmosphere – a matter of significance to the passivity of many metals, and specifically to stainless steel. Body acids so far definitely isolated include hydrochloric, phosphoric, acetic, uric, lactic, butyric, oxalic, ascorbic and gluconic.

Selection of Stainless Steel

At the time of the attack on Pearl Harbor in 1941, the Orthopedic Committee of the National Research Council assigned a project, rated Class A, to C. R. Murray and C. G. Fink at Columbia University, pressing for a quick determination of the most acceptable metal or alloy for bone fixation. Later the Committee on Medical Research of OSRD provided for an extension of these studies by Fink and Smatko. Stainless steel had by this time become an outstanding prospect for such service. Types 302 (18-8) and 316 (18-8 with Mo) were compared with Vitallium, a cobalt-base alloy containing 30% Cr and 5% Mo. The corrodents included a physiological salt solution and several types of serum. Corrosion of the austenitic stainless steels was almost immeasurably small after an exposure of six weeks; and *in vivo* tests with dogs showed no discoloration whatsoever, nor any interference with healing, over a period of six months. Type 302 was accordingly recommended to both the Army and the Navy in 1943.

"Mechanochemical" Cracking – Recently, the term "mechanochemical" was introduced as a generalized reference to those numerous types of failures resulting from a joint action of mechanical stress and chemical attack – stress-corrosion cracking, corrosion fatigue, and certain forms of intergranular attack. The first two of these are transgranular phenomena to which stainless steels were long supposed immune, at least for seemingly noncorrosive environments. The joint A.S.T.M.-A.I.M.E. Symposium on Stress-Corrosion Cracking in 1944 brought serious attention, more or less for the first time, upon the fact that stainless steels were susceptible to mechanochemical attack by certain solutions, but the solutions were of strong and special type. In the decade just past, these steels have been found more sensitive than formerly believed, and

Fig. 2 – Mechanochemical Crack in Test Specimen of Type 316 Stainless Steel Exposed to Ammonium Bisulphite Liquor in a Wood-Pulp Digester. Crevice corrosion developed beneath the locking nut of the stud to produce a fracture remarkably similar to that of Fig. 1. 12 ×. (Courtesy M. A. Scheil, A. O. Smith Corp.)



the instances now to be cited carry the matter to such an unexpected extreme that they should serve as a warning to the surgical and metallurgical professions alike.

Fractured Collison

Figure 1 shows the surgical artifice called a Collison plate, used in bone fixation. It is approximately 4 × 3/8 × 1/16 in., drilled with six holes for anchor pins and formed with a slight curvature around the longitudinal axis. The present specimen was fastened to a patient's right humerus on Nov. 30, 1950; exactly 90 days later, while the patient was in bed, the plate fractured and reopened the wound. In the enlarged view of Fig. 1, minute secondary fissures can be seen near and approximately parallel to the fracture, indicating a cluster of potential fracture foci.

Spectrographic analysis confirmed the material as Type 316 austenitic stainless steel, in agreement with a marking "18-8 S Mo" stamped on the back. Wet analysis, limited by the amount of material available, showed percentages of 0.083 C, 12.98 Ni, and 18.34 Cr, with Mo shown to be present, but not analyzed. Metallographic sectioning revealed a fine-grained monophasic structure, highly directional along the plane of working. Inclusions were not excessive. The fracture path showed no preference for grain boundaries, cutting directly across their elongated forms.

With respect to the several forms of defects to which Type 316 might possibly be subject, special etching revealed no sigma phase; and magnetic testing detected no ferrite. These results conform with the analysis, which indicates a balance in favor of austenite. Special etching for sensitization similarly gave negative results, again to be expected in view of the transgranular path of fracture. Fractographic study of the rupture face confirmed the transgranular features of the traverse.

As a result of these observations, there remains no other form of failure to which these steels are known to be subject with the exception of stress-corrosion cracking and fatigue; the last can be eliminated because joint requirements of the number of flexures and the minimum stress level would render its possibilities too remote. In spite of the complete lack of visible corrosion, the conclusion is drawn that the failure is mechanochemical in nature, rather than mechanical, and that the corrodent accordingly comprised those body fluids to be found between bone and musculature. The instance is particularly remarkable when one recognizes that this type of metal has a tensile strength ranging up toward 200,000 psi. for cold worked conditions, with elongation beginning as high as 50% and still retaining several percent at its highest tensile strength. The bendability of Type 316 is also excellent, even when notched.

Mechanochemical Failures From Perspiration

Interesting corroboration of these conclusions has been provided by M. A. Scheil, to whom the writer is indebted for the photographs and descriptions that follow. In Fig. 2, a failure of

Fig. 3 – Mechanochemical Cracking of Stress-Corrosion Type Found on the Back of a Swiss "Waterproof" Watch Made of Austenitic Stainless Steel. Perspiration as the corrodent has acted in combination with residual internal stresses at eight positions around the circumference where depressions have been formed to seat a spanner wrench. Left – two fissures are indicated by pointers, and others can be found; 3 ×; right – detail of one of these fissures at 12 ×. (Courtesy M. A. Scheil, A. O. Smith Corp.)

this same material carries a close resemblance to the fractured Collison plate. Here the specimen has been exposed to the liquor of an ammonium bisulphite digester used for production of wood pulp. At the end of approximately six months, a crack appeared under the locking nut of the stud. Apparently crevice corrosion was a stage of this failure. As with the Collison plate, microfissuring initiated at the surface of the drilled hole and then opened out to the neighboring edge.

In Fig. 3, the back of a Swiss "waterproof" watch displays mechanochemical fissuring of stress-corrosion type which could scarcely have been caused by anything but human perspiration, so far as a corrodent is concerned. This back cover is attached to the case by an internal thread, requiring a special spanner wrench which seats in eight depressions placed octahedrally around the circumference; and these depressions have served as sites of residual internal stress. Close observation of the left photograph in Fig. 3 will reveal their positions. Pointers designate two of the more prominent cracks leading exactly from the wrench seats, and others can be found. The photo at right shows one of them at higher magnification. Spectrographic analysis confirmed the manufacturer's claim that the metal is 18-8 austenitic stainless steel.

Conclusion – Mechanochemical attack is accordingly more far-reaching than previously supposed, to the extent of the present descriptions where some of the strongest and most corrosion resistant of all metals, the austenitic stainless steels, have failed from stresses not exceeding the residual effects of cold working, and from corrodents no stronger than human perspiration and other products of physiological processes.

The author expresses his indebtedness to M. A. Scheil, director of the metallurgical research department of the A. O. Smith Corp., Milwaukee, Wis., for his contribution of Fig. 2 and 3; also to the Office of Naval Research for partial sponsorship of studies of fracture in the writer's laboratory.

Cleaning With Ultrasonics

*By FRANK W. HIGHTOWER**

Ultrasonic cleaning is particularly helpful where the surfaces to be cleaned are not readily accessible or when they must be scrupulously clean, as for plating or adhesive bonding. (L10)

When high-frequency mechanical vibrations are used in combination with the usual metal cleaning baths, dirt, grease and chips can be removed more quickly, without damage to surface finish. The improvement in cleaning apparently occurs as a result of the mechanical scrubbing action when the bath undergoes cavitation of the type involving the formation and virtually instantaneous collapse of innumerable submicroscopic bubbles.

The effect of the ultrasonic compression waves is very rapid. Figure 1 shows some closely adherent magnetic powder being thrown off from a polished metal surface under the impact of ultrasonic attack.

As long as the material to be cleaned and the transducer are connected by a suitable liquid path, the energy can be applied where it is required. The transducer can be designed to focus the wave energy on a small region within the bath, or to form a beam that creates a zone of intense activity. There is, in effect, a layer of cavitation surrounded by regions of lesser intensity in which there is stirring but no cavitation. The cavitating layer may be either vertical or horizontal, wide or narrow. The work can be moved through it in any convenient manner.

Choice of Frequency and Intensity

One question often raised concerns the wide range of frequencies that are reported in the literature to be effective in cleaning, and the choice of the particular ranges that are used industrially. The explanation must be sought in the way in which a liquid responds to ultrasonic agitation.

During the tension phase of the sound wave, bubbles are formed within the liquid wherever there are imperfections, microscopic nuclei, or adsorbed air. Some grow large enough to pass off from the liquid—"degassing". Some expand, and then contract quietly in the compression phase. If the size after expansion exceeds a critical ratio to the initial size, the bubble will burst and "crash" or cavitate, and it is only these that contribute a cleaning effect. Energy used for expansion of the noncavitating bubbles is wasted. The proportion of bubbles that reach the cavitation ratio is greater at lower frequencies. The increase in intensity required to initiate visible cavitation as the frequency rises is shown by the curve in Fig. 2.

The energy input that will maintain cavitation, once the cavitation threshold has been reached, is about half the initial cavitation values. If driving intensities are increased, more cavitation occurs at the face of a transducer. This layer of bubbles reduces the energy available in the liquid because it distorts the plane parallel wave front and the energy dissipates or scatters.

To clean metal parts of any size whatever, there must be an effective cleaning zone at least a few inches from the face of the transducer. It is better to hold the energy intensity imposed on the transducer down to a level at which there is only a moderate cavitation at the face and an undistorted wave front.

Our observations indicate that a few watts per square inch applied to a flat transducer of about 40 kc. frequency will be considerably more effective in cleaning large areas or sections of metal than several times the input per unit of

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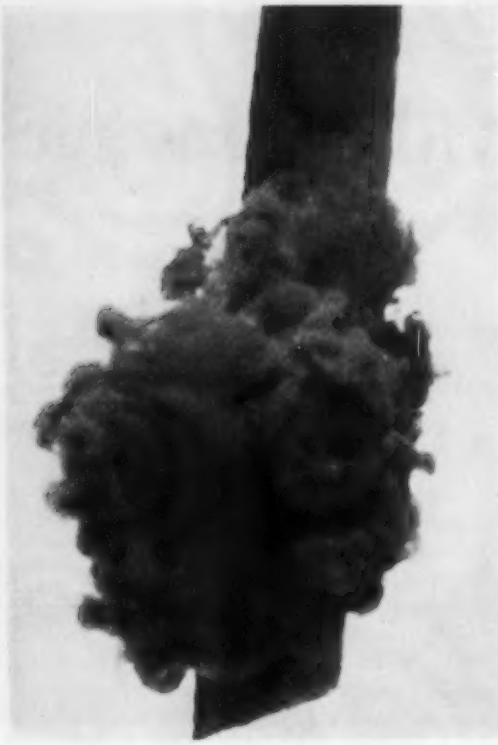


Fig. 1 – Separation of Magnetic Powder From a Polished Steel Surface Shown at the Instant Energy Was Applied to Transducer

surface applied to a 400-kc. transducer. See curve in Fig. 3.

Another factor that must be considered in selecting the frequency for a cleaning unit is the desirability of a certain amount of spread or divergence of the wave pattern to prevent "shadowing" and increase the cleaning area. At high frequencies the energy beam travels in a very narrow path, so that little of the ultrasonic energy reaches the surfaces away from the transducer.

From these considerations it appears that the practical range for metal cleaning is from approximately 25 kc. (below this frequency there is the discomfort to personnel on account of audible squeals) to about 400 kc.

Every portion of the piece to be cleaned must be exposed within the cavitation zone for a time long enough to clean it completely. This is in part a problem in arrangement of the transducers, but the transducer area required will depend on the size of the units to be cleaned and on the rate. There is no way to make a general rule on this, but perhaps the information to be given in the section "Typical Installations" will help to indicate probable sizes.

Transducer Materials

Piezo-electric materials such as quartz and pre-polarized barium titanate change in thickness under an applied voltage. The dimensional change reverses with the changing polarity of the applied alternating potential, and is proportional to the imposed voltage. By matching the frequency of the activating voltage with the natural resonant frequency of the transducer, a considerable gain in amplitude of the mechanical response can be realized, while holding the internal energy losses to a minimum.

Quartz transducers were used in the first industrial ultrasonic cleaning installations, and this type of equipment is still preferred by many for certain applications. The transducer consists of a slice from a single crystal, cut parallel to the X-axis and lapped to uniform thickness. It must be free from electrical twinning. The usual size of these in commercial equipment is from about 1½ to 2¾ in. diameter. The cleaning zone can be increased in size by mounting several disks in a transducer unit. The preferred practice is to put them at an angle to one another in order to reduce shadowing.

The frequency is an inherent characteristic of any given quartz disk, depending on the thickness. The thinner the disk, the higher the frequency will be.

Equipment embodying quartz transducers is available commercially in 300-kc., 700-kc., and higher frequencies. Input power levels on the order of 75 to 250 watts per sq. in. of radiating surface have been reported.

Relatively high impressed voltages are necessary because of the high impedance of the quartz crystal. For instance, a 400-kc. transducer approximately ¼ in. thick may be under 10 to 20 kv. of radio-frequency potential. Hence the crystals are usually mounted in a high dielectric oil that transmits the ultrasonic vibrations to a suitable diaphragm set in the treatment vessel. Alternately, the radiating face of the crystal may be fastened to a thin metal diaphragm mounted in a housing so that the crystal can be surrounded with moisture-free air under pressure. The latter type is claimed to be somewhat more efficient. A quartz transducer may be operated at temperatures up to 450 or 500° F. without impairing its piezo-electric property.

Titanate – Transducers of barium titanate ceramics can be built in sizes, shapes and fre-

quencies offering a choice of design for various applications, since this polycrystalline material can be fabricated like any other ceramic.

Shapes are extruded, cast or molded, and then fired in the desired configuration. After metallic electrodes are baked on opposite faces of the piece, it must be polarized by applying a high potential (30,000 v. per in. of thickness between the electroded faces). The polarization treatment produces a crystal domain structure having piezo-electric response.

Curved shapes are used to focus the vibrational energy so as to produce high energy intensities within the liquid. Flat transducers of any desired radiating area are built up from

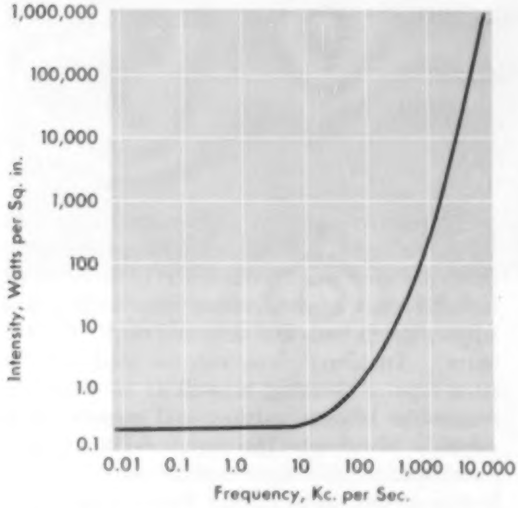


Fig. 2 – Minimum Power (Energy Intensity) Needed to Start Cavitation in Ordinary "Gassy" Water, Measured at Different Frequencies Between 1.5 and 3300 Kc.

standard size bars or plates. Six inches is about the maximum diameter of the cylinders available, due to production problems introduced when large titanate ceramic tubes are fabricated. For production cleaning, the cylinders are split lengthwise into 120° segments. Hemispherical bowls up to 4 in. diameter are also used.

Frequencies of titanate cleaning units may range from below 20 to 450 kc. The frequency at which any one element can be operated effectively is a function of the distance between the electroded faces of that element.

It has been customary to mount the ceramic transducers directly in the cleaning bath. This restricts choice to nonconductive baths. Laboratory units have been operated with electrolytes and corrosive chemicals.

Barium titanate compositions now available are limited to operating temperatures below 160° F., except in the higher frequency range.

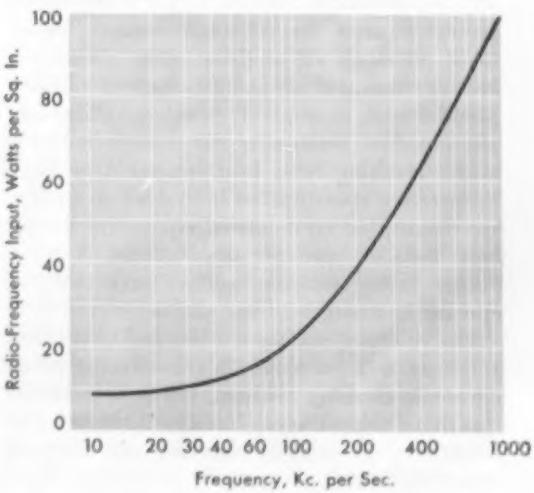
Magnetostriction – The property of changing dimension with change in magnetizing force is characteristic of certain alloys of nickel, iron and cobalt. When such a bar is placed with its longitudinal axis parallel to a magnetic field, its length changes in proportion to the magnetic flux. The effect is utilized to form transducers by applying a unidirectional magnetic field upon which an alternating field of suitable frequency is superimposed.

Commercial magnetostrictive transducers generally consist of a stack of thin nickel alloy laminations, rigidly attached to a flat surface which couples the energy into a liquid or solid. The size of the working heads of the vibrating units is held to about 2 × 2 in. or less. They operate most effectively in the frequency range between 4 and about 60 kc., although units having a frequency as high as 175 kc. have been built for laboratory use.

Practicable intensities in radio-frequency power delivered to the transducer range from about 50 to several hundred watts per square inch, and the operating temperature probably can go as high as 300 or 350° F.

The head of the vibrator may be immersed directly in a solvent, but more commonly it is

Fig. 3 – Power Required to Remove Nonsoluble Soil Completely From Standard Specimens Under Controlled Conditions. Flat transducers, in cold trichlorethylene, were used at frequencies from 10 to about 400 kc.



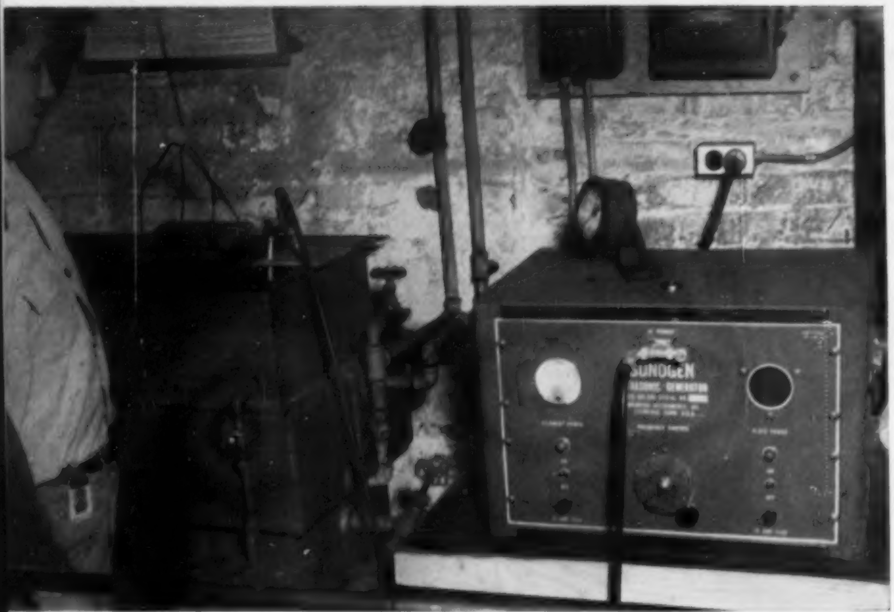


Fig. 4 – Equipment for Cleaning Machined and Lapped Parts in a Trichlorethylene Bath Using a Focused Titanate Transducer – Dip Operation

attached to the tank wall or to a diaphragm, and the sound waves are transmitted through the metal container into the cleaning medium. This has the advantage that it permits a wide choice of solutions or solvents, depending on the selection of container material. Containers up to about a foot or two in diameter are commercially available, with multiple transducer units mounted in the bottom.

What Can Be Cleaned

Because the cleaning process is fundamentally a mechanical one, it is not selective as to the articles cleaned or the type of soil removed. At present most of the ultrasonic cleaning operations, including all of those to be mentioned, involve removal of oils and greases or of adherent particles such as magnetic powders. Ultrasonically expedited removal of the strongly adherent oxides resulting from heat treatment or high-temperature operation has been done on a laboratory basis, but no industrial equipment has yet been installed, pending development of transducers having sufficient surface area that can operate in strong acids or alkalis.

The volatility, surface tension, and viscosity of a solvent will influence its effectiveness as an ultrasonic cleaning medium, but it is generally true that a solvent which has already been found satisfactory in ordinary cleaning can be used under ultrasonic operation.

Light petroleum distillates or emulsifiable oil solvent systems that permit subsequent water rinses are used when the material to be removed includes shop grease, cutting oils, buffing and lapping compounds and detached chips (but not burrs). Trichlorethylene can be used for the same type of cleaning, as well as on difficultly removable silicone greases and molybdenum sulphide lubricants. The higher boiling chlorinated hydrocarbons seem to clean more effectively than do straight petroleum distillates that have much the same viscosity and surface tension, but greater volatility at the same temperature.

The use of ultrasonic equipment with these degreasing media is justified when it very greatly reduces time of cleaning, when it facilitates inspection or eliminates returns because of unsatisfactory cleaning, and for those parts where expedients such as brushes have been necessary to supplement solvent cleaning. Also, ultrasonics may permit the use of less complex solvents for cleaning jobs that require baths of extremely high solvent power; however, at present special problems such as these must be worked out by laboratory trials.

Typical Installations – Ultrasonic cleaning is now being applied to material between manufacturing operations, to finished components before assembly, to partial assemblies and finished mechanisms, as well as in maintenance and reconditioning.

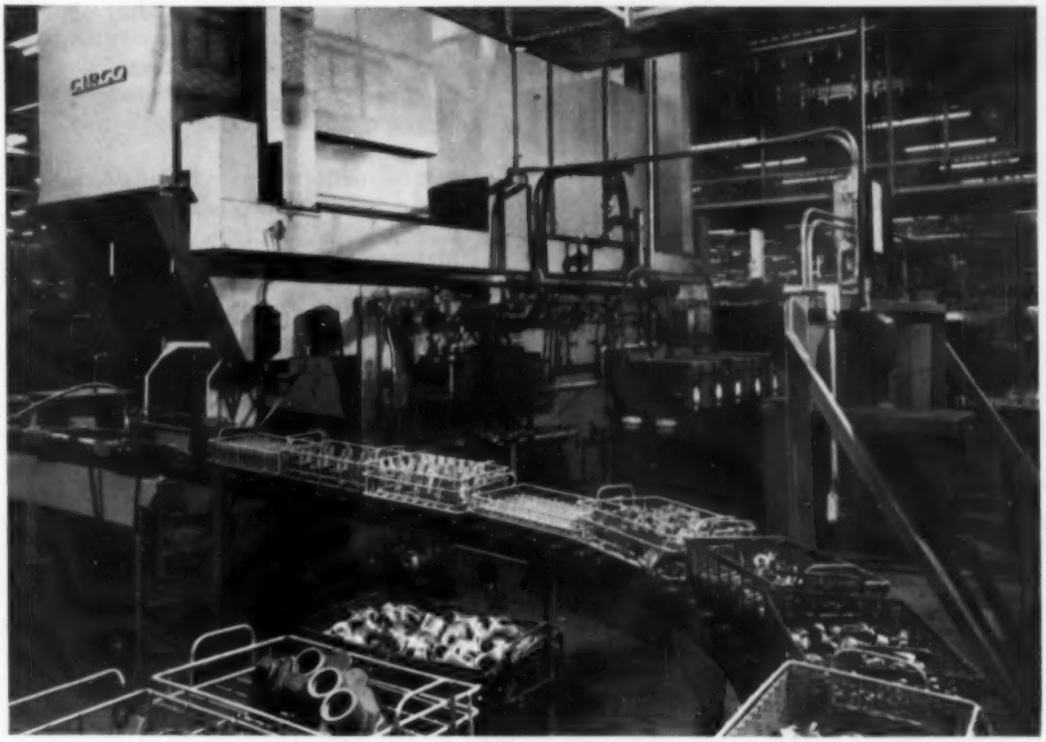


Fig. 5 – This Ultrasonic System Cleans 1000 lb. of Automobile Steering Assemblies in One Hour

Ultrasonic cleaning equipment is used to remove lapping compound, chips and cutting oils from honed ball bearing races (⅜ to 2 in. diameter) prior to final assembly. The cleaning is done in a mineral seal oil bath with a focused titanate transducer of the 120° sector type having an effective length of 12 in. They move through the zone of ultrasonic cleaning at the rate of about 4 in. per sec.

In another installation, also a final cleaning before assembly, machined parts for motive power control equipment are processed in trichlorethylene at 140 to 160° F. over 100-kc. flat bar transducer elements having a total radiating surface of about 360 sq. in. Between 2000 and 3000 lb. of metal is handled in an hour.

A fully automatic operation for cleaning automobile steering assemblies is shown in Fig. 5. The ultrasonic section of the system has approximately 180 sq.in. of transducer area and cleans 1000 lb. of metal in an hour. The assemblies are first cleaned at 120 to 140° F. in ultrasonically activated trichlorethylene; then as they come out of the tank they are rinsed with cold solvent and go into a vapor degreaser which acts as a drier.

Ultrasonic cleaning should precede vapor degreasing, if both are used. If the vapor degreaser is used first, it may extract readily soluble oils present on the part and heat-set the solids, so that even the best ultrasonic operation following will take much longer for the cleaning than if no vapor degreasing had been done. On the other hand, vapor degreasing after the ultrasonic cleaning will eliminate difficulties with draining and drying the parts, and is recommended.

For watch movements, where cleanliness standards are very high, two or three ultrasonic stages are used. A focused transducer about 430 kc., at an intensity of 30 watts per sq.in., has been found satisfactory with a batch-type operation. The first cleaning is generally done in a light petroleum distillate with some organic soap. The second ultrasonic step is really a very thorough rinse, and any suitable organic solvent may be used. Extreme care is always necessary in drying small precision mechanisms, and there will be a series of rinses without intermediate drying, preferably followed with warm, dry air after final rinse.

Ultrasonic equipment is being used both in maintenance and reconditioning, but these are batch operations under varying conditions and

no data on typical installations are available at the moment.

Limitations – The ultrasonic energy will assist a solvent to remove dirt from the interior of hollow parts or from between very close fits, but there are limits to what can be done. For example, there is the familiar practice of packing ball bearings in heavy grease for storage. In a liquid that is not solvent for the grease the ultrasonic cleaning bath will remove it very well from all accessible portions, but ultrasonics cannot remove the grease from the interior where the cleaning liquid cannot be forced in.

Also, there has been a tendency sometimes to overlook the fact that the relation of the object to be cleaned and the ultrasonic cleaning bath must be such that sufficient mechanical energy reaches all of the surfaces that are to be cleaned. Unless the transducer is big enough or the part to be cleaned is moved around or rotated so that each portion is subjected to an intensity above the cavitation threshold, the ultrasonic effect is lost. Several reported failures have been traced solely to the attempt to do a production line job with laboratory-type equipment.

Equipment

Various factors may influence choice among the transducer types available, but the first step is to select a transducer having adequate area and delivering adequate mechanical energy for the job to be done; the rest of the installation can be adapted to the materials handling procedures desired.

Transducers can be used in any position except radiating downward or at such an angle that the bubbles arising in the cavitating liquid will collect across the face of the transducer. Flat or curved units may be located slightly above the bottom of the tank, radiating upward, or they may be positioned along one or both sides, beaming across the liquid. The latter arrangement is frequently used in equipment where the work travels on a conveyer past multiple transducers. One manufacturer is marketing a tank with a pair of flat quartz transducers set in the two faces of a V so as to reduce shadowing.

All installations should provide means for filtering and recirculating the cleaning liquid. In addition to filtering, redistilling may be needed if there is much soluble material picked up by the liquid.

Tanks, washers and degreasers that have an ultrasonic stage need be no larger than similar washers or degreasers without ultrasonics. In fact, many plants have converted existing tanks and degreasers by putting transducers in the bottom or hanging them on the sides of the tank. This has been done with quartz and with barium titanate elements.

Magnetostriction equipment available to date is constructed with the vibrating element and the tank as an integral unit. This can be substituted for existing dip tanks in the conversion of cleaning lines.

Established manufacturers of washers and degreasers will supply designs and equipment for new cleaning lines incorporating an ultrasonic step of any suitable type, and for small parts cleaning, particularly in batch operations, package units that include the necessary solvent handling equipment are available for all three transducer types.

Generators – Most of the commercial generators now available use vacuum tubes in electronic oscillator-amplifier circuits, somewhat like the power sources for induction heating.

Present-day generators are relatively small, compact units requiring surprisingly little floor space for the amount of electrical and electronic gear packed inside the cabinets. They operate on 110 or 220-v., single-phase current, except in the larger sizes, which may be built to take 440-v., three-phase current. Units presently on the market range from about 20 watts to 25 kilowatts of radio-frequency power delivered to the transducer. The frequency is adjusted at the factory to match the transducer selected. Operating controls are on-off switches, or at most a dial or two for tuning and power control.

Costs

In very general terms, cost of transducer plus generator is in the range of $2 to $5 per radio-frequency watt for units between 50 and about 500 watts output. There is a tendency for the relative cost to be lower as the rated power increases, to about $1 to $2 per watt for large installations.

Regardless of type, effective transducer area is the best basis for figuring costs. In terms of transducer area, equipment is quoted all the way from approximately $20 to several hundred dollars per square inch. These figures include generator, transducer, and accessories, but not tanks, piping, solvents and related supplies. Thus $20,000 would be a rough minimum estimate for 1,000 sq. in. of transducer area and the generator to drive it.

4 Times the Life-Span of "Gray" Iron

Harnischfeger gets longer life and easier fabrication from Ductile Cast Iron

In solving a machining problem, Harnischfeger Corporation discovered how to greatly increase life of sheaves handling wire rope on their overhead cranes.

The problem arose in machining sheaves of gray cast iron. Chill at the top and corners of rope grooves caused cutting tool breakage.

When Harnischfeger annealed these castings to improve machinability, the base or bottom of the rope grooves were softened. Ranging from 140 to 196 BHN, the softened grooves wore out prematurely and frequent replacements were needed . . . wasting valuable hours of production time.

Ductile Cast Iron the answer

Ductile iron, which has excellent wear resistance, solved the problem.

Although the hardness of the Ductile Cast Iron was higher (240-269 BHN) than that of cast iron, it was free of chill at the edges and machined readily. But especially important in handling wire rope, the wear resistance provided by Ductile Cast Iron gave the sheaves a 4 to 1 longer life than gray iron.

This is a simple example, showing how you get multiple savings by using Ductile Cast Iron. For here's a material with the castability of cast iron, and properties similar to those of cast steel.

Get all the facts about the impact strength, wear resistance and machinability of this economical cast iron. It's several times stronger and tougher than gray cast iron. Send for a copy of "DUCTILE IRON, The Cast Iron THAT CAN BE BENT!" It's filled with helpful data. Write for your copy now.

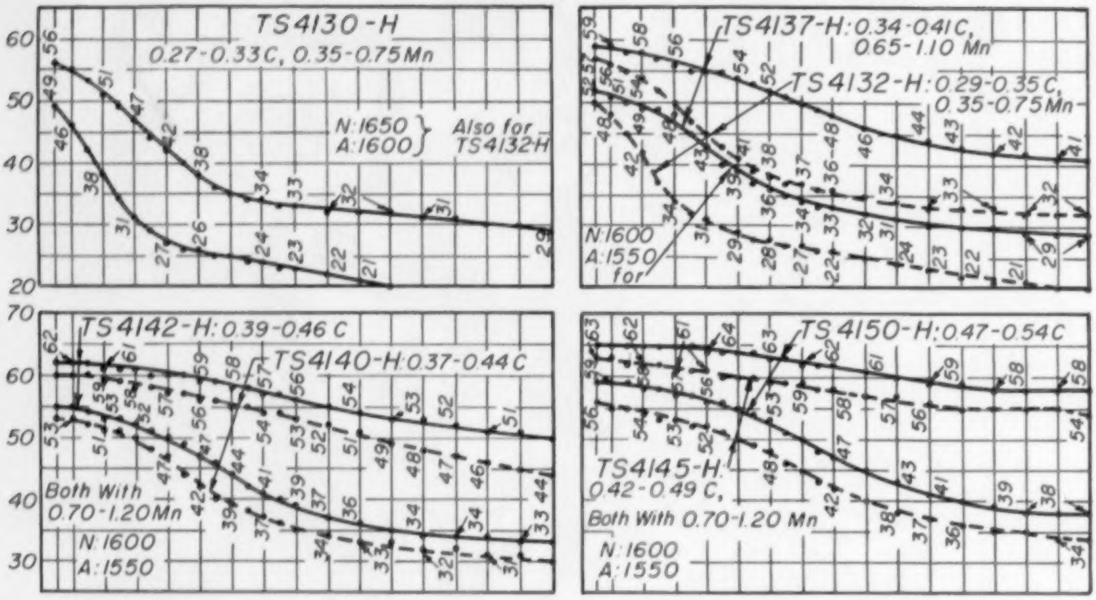
Way to cut downtime of overhead traveling crane. Grapple shown at work in lumber shed is equipped with sheaves of Ductile Cast Iron. Readily machinable, but resistant to wear from wire rope, they outlast gray iron sheaves 4 to 1. Equipment produced by Harnischfeger Corp., Milwaukee 46, Wisc.

ductile iron . . . the cast iron that can be twisted and bent

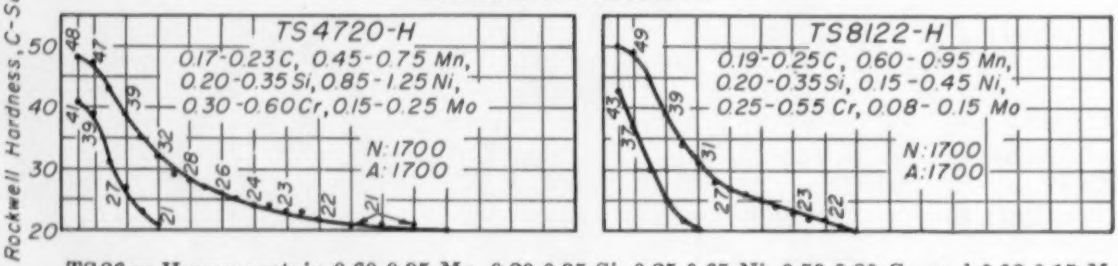
THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N. Y.

Tentative Standard H-Steels

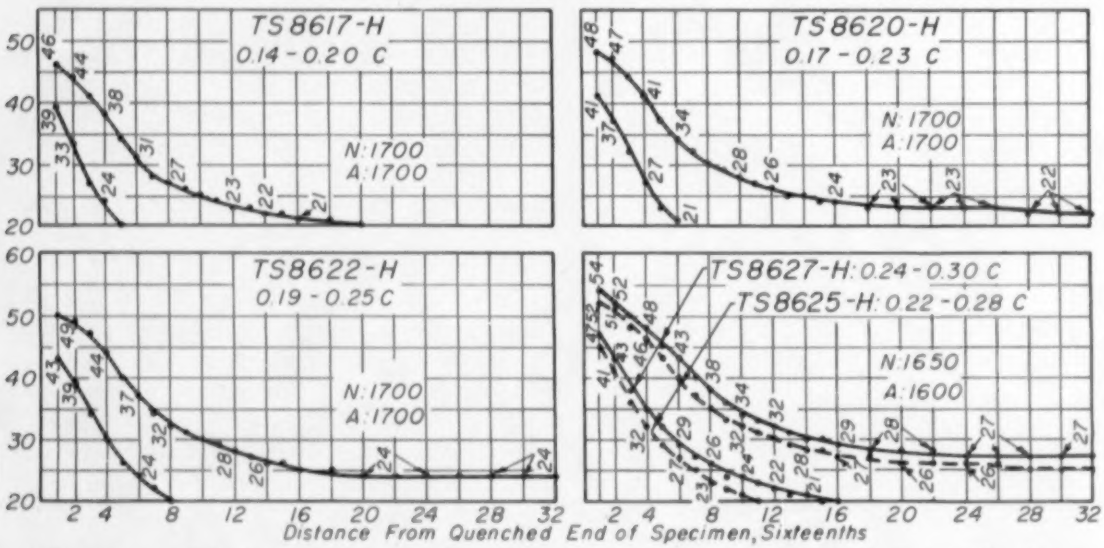
TS41xx-H may contain 0.20-0.35 Si, 0.85-1.30 Cr, and 0.08-0.15 Mo



TS 4720-H and TS 8122-H



TS86xx-H may contain 0.60-0.95 Mn, 0.20-0.35 Si, 0.25-0.65 Ni, 0.50-0.80 Cr, and 0.08-0.15 Mo



N means normalizing temperature for forged or rolled material; A means austenitizing temperature (both as recommended by S.A.E.).

Hardness limits are specified in Rockwell C-scale units (no fractions) and can be scaled from the plotted points where not labeled at even sixteenths.

A.I.S.I. list of February 1954.

Properties of Arc-Cast Molybdenum

*By NORMAN L. DEUBLE**

The high-temperature strength of molybdenum is significantly increased by alloying to well above the levels obtained with conventional gas-turbine alloys. (Q general, Mo)

The properties of unalloyed molybdenum have been satisfactory for most electric and electronic applications, which until recently accounted for almost all its uses. With the introduction of the arc-casting process, however, emphasis has shifted to engineering applications at high temperatures, where alloys are necessary for better strength.

The Office of Naval Research sponsored a program at Climax Molybdenum Co. of Michigan to determine the effect of 20 elements on the properties of molybdenum. Some of these alloys were completely soluble in molybdenum over the range examined; others, merely within a limited range. The alloys that contained intermetallic compounds proved to be too hard to process with available facilities. Therefore intensive development is being confined at present to solid-solution alloys, which depend entirely on mechanical working for strengthening. The following four alloys in this category are now considered commercial: 0.3% Cb; 0.5% Ti; 1% V; 2% W. The first three have higher strength at elevated temperatures than unalloyed molybdenum; the last has superior weldability. Research is continuing on other alloys that may become commercial with development of improved fabricating methods.

Physical and Mechanical Properties

As far as is known, there is no significant difference in physical properties between unalloyed powder-metallurgy and arc-cast molybdenum, provided the former has been worked sufficiently to give a density approaching the theoretical value of 10.223 g. per cc. Unalloyed arc-cast molybdenum in all conditions, including arc-cast ingots, has this density. The present commercial arc-cast alloys may be considered to have substantially the same density as unalloyed arc-cast molybdenum.

Notable among the physical properties of molybdenum are its high melting point (4730° F.) and its exceptionally high modulus of elasticity. (Young's modulus and modulus of rigidity at 80, 500, 1400 and 1600° F., are, respectively, 46.0, 43.2, 39.9 and 39.9, and 17.4, 16.4, 15.1 and 15.1 million psi.). In fact, the Young's modulus of molybdenum at 1600° F. is about a third greater than that of steel at room temperature.

The excellent resistance of molybdenum to cracking on repeated heating and cooling is indicated by the combination of high thermal conductivity with low coefficient of expansion. While these properties have not been determined as yet on all four commercial alloys, some work has indicated that alloying additions in the amounts now used cause only relatively minor changes (Fig. 12).

The mechanical properties of molybdenum are governed largely by the amount of mechanical working done below its recrystallization temperature. The four arc-cast molybdenum-base alloys offered commercially today by Climax are similar to unalloyed molybdenum in that they are not heat treatable and depend on mechanical working for strengthening.

Room-temperature properties of molybdenum and its alloys are extremely sensitive to mechanical and thermal treatment, strain rate, stress system and purity. Careful processing is required to obtain best properties.

*Manager, Metallurgical Development Div., Climax Molybdenum Co., New York City. This is the fourth article in a series on arc-cast molybdenum that started in the April issue.

Table II – Effect of Processing on Room-Temperature Properties of 2% Tungsten Alloy*

Specimen†		Strength, Psi.		Elongation, §	Reduction of Area
Diam.	Condition	Tensile	Yield‡		
1/2 in.	As rolled	122,300	112,400	29%	61.7%
1/2	Stress-relieved (*a*)	101,400	83,200	38	67.7
1/2	Recrystallized (*b*)	71,200	46,800	62	68.5
1 5/16	As rolled	76,400	69,400	13	11.6
1 5/16	Stress-relieved (*a*)	77,600	69,800	23	18.1
1 5/16	Recrystallized (*b*)	66,700	49,800	46	34.8

*0.04% C, 2.15% W, remainder Mo; values are the average of two tests.
†Rolled bar.
‡Drop of beam.
§1/4-In. diameter specimens, 1-in. gage length; tested at strain rate of 3% per hr. in elastic range, 60% per hr. in plastic range.
(*a*) 1 hr. at 1850° F.; (*b*) 1 hr. at 2300° F.

Table III – Effect of Size of Test Specimens on Room-Temperature Tensile Properties of 2% Tungsten Alloy

Specimen		Strength, Psi.		Elongation‡	Reduction of Area
Condition	Diam.*	Tensile	Yield†		
As rolled	1/2 in.	83,200	72,200	4.0%	3.8%
	1/4	76,400	69,500	13.0	11.7
After 1 hr.	1/2	76,300	69,700	6.0	5.1
at 1800° F.		77,300	70,010	3.5	3.0
	1/4	77,300	68,800	37.0	43.6
		77,600	69,900	23.5	18.2
After 1 hr.	1/2	66,400	49,600	30.5	23.6
at 2300° F.	1/4	66,700	49,800	46.0	34.9

*Test specimens cut from rolled 7/8-in. bar.
†Drop of beam.
‡In 1 in. for 0.250-in. diameter specimens; in 2 in. for 0.500-in. diameter specimens.

Hardness and strength at room temperature increase with increasing amounts of mechanical working below the recrystallization temperature. By swaging and drawing to fine wire, tensile strengths up to 300,000 psi. may be obtained. When mechanically worked molybdenum is reheated at increasing temperatures, evidence of recrystallization is shown by a sudden drop in hardness at room temperature. The temperature at which this occurs depends on composition as well as on the amount of mechanical working. A large loss in room-temperature strength therefore accompanies recrystallization of mechanically worked molybdenum. Stress-relieving below the recrystallization temperature increases the elongation but has only a relatively small effect on strength. The effect of processing on the mechanical properties of a tungsten-molybdenum alloy with room-temperature tensile properties similar to those of unalloyed molybdenum is shown in Table II.

The ductility and toughness at room temperature are greatly affected by the strain rate. An increase in the strain rate used for testing may easily shift the tensile transition temperature from slightly below to slightly above room temperature. Strain rate must therefore be controlled in testing molybdenum. Our laboratory has obtained the most consistent results with strain rates of 3% per hr. within the elastic range and 60% per hr. within the plastic range. Changes in the size of the tensile specimen also affect the properties of molybdenum more than those of most other metals; elongation and reduction of area are primarily affected (Table III).

Transition Temperature – Molybdenum, like ferrous metals, displays a so-called transition temperature at which a change from ductile to brittle behavior takes place as the temperature is lowered. The position of the transition tem-

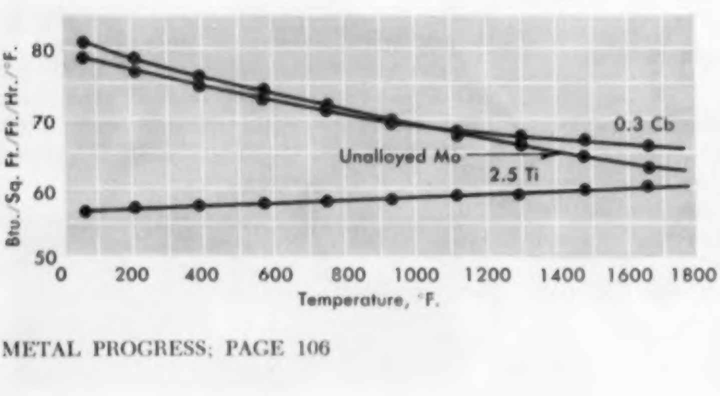
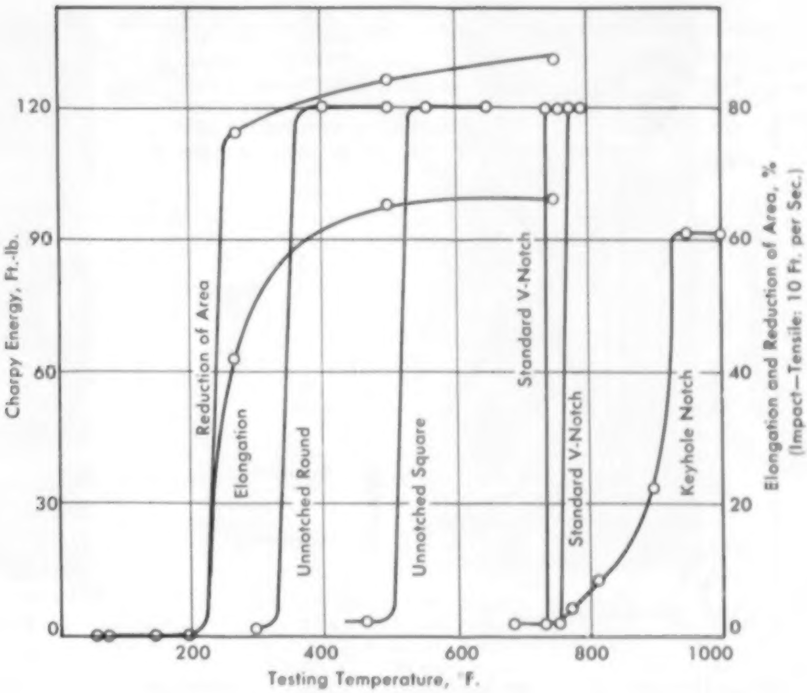


Fig. 12 – Effect of Temperature and Alloying on the Thermal Conductivity of Molybdenum

Fig. 13 – Effect of Temperature on the Toughness and Ductility of Recrystallized Molybdenum for Various Stress Systems



perature depends not only on the purity of molybdenum and its thermal and mechanical history, but also on the strain rate and stress system, Fig. 13. The ductility and toughness of a sample increase with increasing temperature, with decreasing strain rate, and with decreasing restraint imposed by bi-axial or tri-axial tension. Therefore, although the transition from ductile to brittle takes place in a relatively narrow temperature range in any one type of test, the transition temperature of a specific bar may vary over several hundred degrees, depending on the criterion used to determine it.

The effect of processing on the transition temperature is not constant but is affected by composition and method of testing; see Table IV and Fig. 14 and 15.

Table IV – Effect of Composition and Processing on Tensile Transition Temperature Ranges

Specimen: Composition	Specimen: Condition	Transition Ranges*
0.015% C	As rolled	+15 to +50
	Stress-relieved	+20 to +32
	Recrystallized	+14 to +20
0.021% C, 0.46% Ti	As rolled	−35 to −30
	Stress-relieved	−35 to −30
0.024% C, 0.45% Ti	Recrystallized	−30 to −15

*Based on elongation in tensile test; ° F.

Elevated-Temperature Properties – One of the properties most desired in metals to be used at elevated temperatures is a high recrystallization temperature. Recrystallization removes the strengthening resulting from mechanical working; therefore, higher recrystallization temperatures permit taking advantage of this strengthening at higher operating temperatures. Table V shows the increase in recrystallization temperature that can be gained by small additions of columbium, titanium and vanadium as compared to unalloyed molybdenum.

Since some of the main applications contemplated for molybdenum and its alloys involve

Table V – Effect of Composition on Recrystallization Temperature

Composition	Recrystallization Temperature*: 5/8-In. Round	Recrystallization Temperature*: 1-In. Round
Unalloyed Mo	2150° F.	2200° F.
0.24% Cb	2200	2500
0.45% Ti	2450	2600
1.02% V	2150	2350

*1 hr. at temperature.

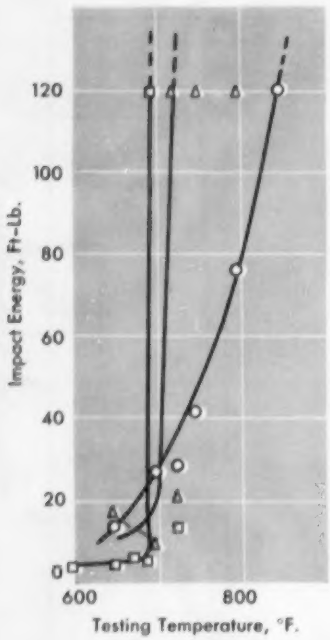
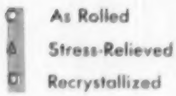
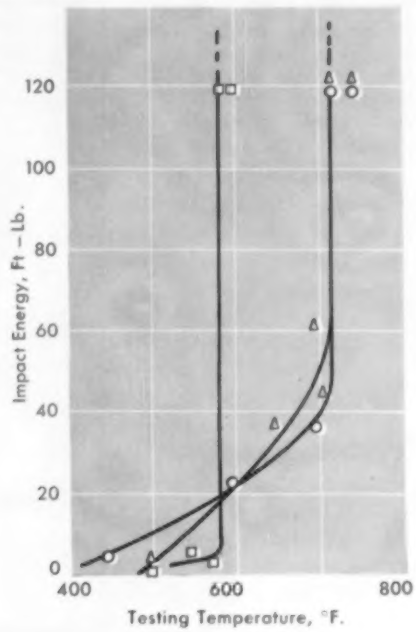


Fig. 14 and 15 – Effect of Processing on the Impact (V-Notch) Transition Temperature. Unalloyed molybdenum (containing 0.015% C) at left; 0.45% Ti alloy at right





elevated temperatures, the load-carrying ability at these temperatures is of prime importance. The comparative mechanical properties at room and elevated temperatures have been determined on unalloyed molybdenum and three of the commercial molybdenum-base alloys processed under conditions as nearly alike as possible. Some of these data for unalloyed molyb-

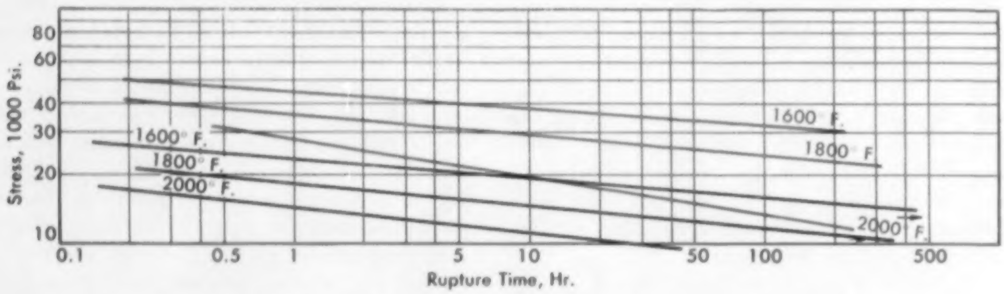
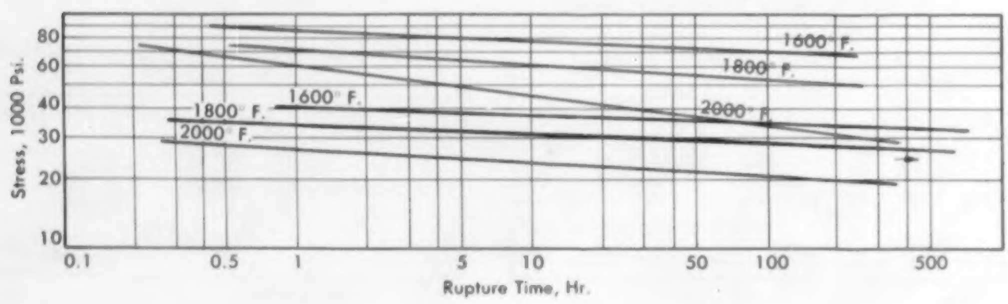


Fig. 16 and 17 – Effect of Temperature and Processing on Rupture Strength. Unalloyed molybdenum above; 0.45% Ti alloy below. Curves in color for stress-relieved condition; black curves for recrystallized. Tested in vacuum.



denum and the 0.45% Ti alloy, which seems to have the best combination of room and elevated-temperature properties, are shown in Table VI and Fig. 16 and 17. The 0.24% Cb and 1% V alloys have slightly lower strength than the 0.45% Ti alloy. The 2% W alloy has substantially the same elevated-temperature properties as unalloyed molybdenum, although its weldability is superior.

The ductility of molydenum and its alloys at elevated temperatures is ample for almost any application. In virtually every instance the final elongation in stress-rupture tests was over 10% for stress-relieved specimens and two to three times greater for fully recrystallized specimens. The high values for reduction of area (generally over 50%) found in ruptured specimens indicate substantial localized deformation.

The effect of alloy content on elevated-temperature properties

Table VI – Effect of Alloy Content and Processing on Room and Elevated-Temperature Properties of Molybdenum Alloys.

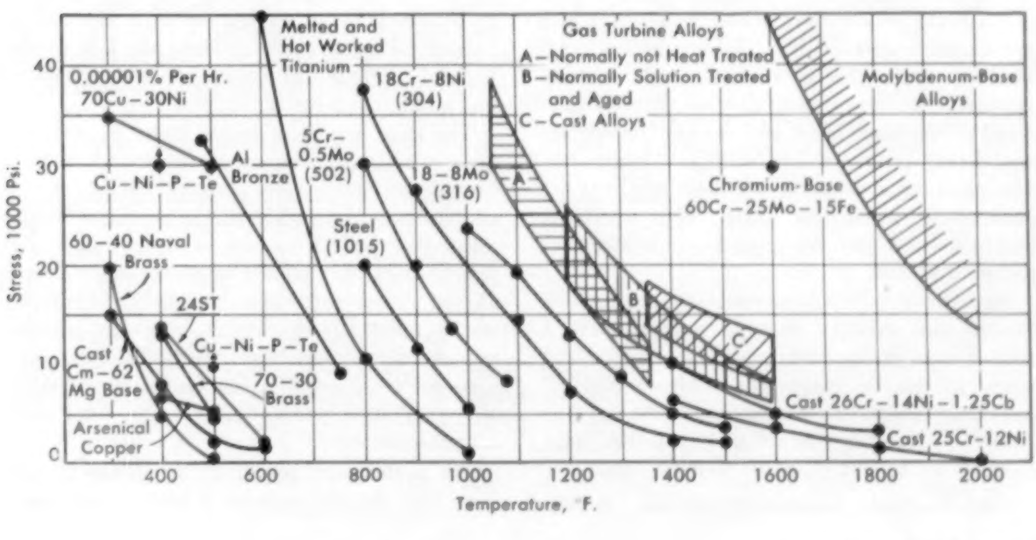
Condition	Testing Temp.	Strength, Psi. Tensile	Strength, Psi. Yield	Elongation*	Reduction of Area
Unalloyed Molybdenum, 0.015% C; 5/8-In. Diameter Rolled Bar					
As rolled	81° F.	102,200	78,800†	40%	61.1%
	1200	69,600	49,800†	18	84.2
	1600	52,000	37,000†	24	88.6
Stress-relieved (a)	81	97,200	82,900†	42	69.0
	1200	65,200	48,100†	22	86.1
	1600	52,400	33,400†	24	88.6
Recrystallized (2150° F.) (b)	81	68,200	55,900	42	37.8
	1200	33,600	11,000	57	84.8
	1600	25,100	7,600†	60	84.6
0.45% Ti Alloy; 5/8-In. Diameter Rolled Bar					
As rolled	82	112,900	96,700†	29	59.7
	1200	101,300	80,600†	18	82.6
	1600	86,900	81,000†	17	84.0
Stress-relieved (a)	80	132,100	99,100†	31	70.0
	1200	100,500	84,000†	17	74.1
	1600	88,300	76,500†	15	71.1
Recrystallized (2450° F.) (b)	81	75,500	60,000	55	38.0
	1200	43,700	—	45	86.2
	1600	39,900	15,400	47	88.4
0.45% Ti Alloy; 1-In. Diameter Rolled Bar					
As rolled	77	115,100	89,000†	30	46.8
	1200	84,900	68,300†	15.5	74.5
	1600	78,400	64,800†	15.5	75.0
Stress-relieved (a)	83	113,000	87,900†	20	25.4
	1200	84,700	62,600†	16	71.9
	1600	77,700	62,800†	16	75.7
Recrystallized (2600° F.) (b)	74	72,500	53,900	22	18.7
	1200	39,200	10,300	42.5	87.7
	1600	37,500	14,500	48.5	87.6

*0.1% offset yield strength taken from stress-strain plot; all other yield strength values from drop in load.

†In 1 in. for 0.250-in. diameter specimens from 5/8-in. bars; in 2 in. for 0.430-in. diameter specimens from 1-in. bars.

(a) 1 hr. at 1800° F. (b) 1 hr. at indicated temperature.

Fig. 18 – Comparative Creep Strength of Molybdenum-Base Alloys and Other Alloys Used at Elevated Temperatures. Based on secondary-creep rate of 0.0001% per hr.



is pronounced. On the whole, the 0.45% Ti alloy had the best strength, with unalloyed molybdenum lowest, and the 0.24% Cb and 1.02% V alloys intermediate.

Prior processing has a marked influence. Generally, fully recrystallized samples had about 40 to 50% lower rupture strength (100 hr.) at 1600° F. than stress-relieved material of the same grade. The difference lessened as the testing temperature increased in relation to the recrystallization temperature. The 0.45% Ti alloy with the highest recrystallization temperature showed no recrystallization during tests run at 2000° F.; therefore, stress-relieved material still had appreciably higher strength than fully recrystallized. With unalloyed molybdenum, on the other hand, recrystallization took place during the holding of the stress-relieved specimens at 2000° F., with the result that stress-relieved and fully recrystallized specimens had essentially the same final strength at the conclusion of testing. This emphasizes the importance of alloying additions that increase the recrystallization temperature.

The outstanding strength of molybdenum-base alloys at high temperatures compared to other metals and alloys is emphasized by Fig. 18. It is obvious that the creep strength of molybdenum-base alloys far exceeds that of other metals and alloys at temperatures above 1600° F.

High Strength Steel Parts ... by New Powder Metallurgy Process

(H general, ST)

*By JOHN W. YOUNG**

STEEL PARTS from metal powders which are characterized by high density and a combination of hardness, strength and ductility approaching very closely that of wrought material of the same alloy and carbon content are now being produced by Isthmian Metals, Inc. The mechanical properties of these products are particularly suited for small, close-tolerance, highly stressed parts for guns, business machines and instruments.

Steel produced by these processes can be heat treated like ordinary wrought steel to yield a wide range of hardness and a corresponding range of tensile properties. The mechanical properties which can be obtained with the two grades produced are shown in Fig. 1. The composition of Grade A is similar to S.A.E. 1080 and is obtained by carburization of a low-carbon (about 0.10%) steel compact. Grade B is similar to S.A.E. 1060 but all the carbon is incorporated in the original powder mixture.

The most important single factor in attaining high mechanical properties was found to be a high density ratio (low porosity). Whereas tensile strength is roughly proportional to density ratio, other properties such as elongation, reduction of area and impact strength show a very abrupt improvement at a "threshold" density ratio of about 97%. Figure 2 shows the relation between density ratio and reduction of area measured on tensile test specimens. Density ratios above 98% of full density are readily obtainable with the process.

The preliminary processing necessary to produce high density includes selection and blend-

*Vice-President, Isthmian Metals, Inc., Boston.

ing of the powder mixture, briquetting, sintering and coining. Some carbon may be introduced in the original powder mixture but if the steel is to contain a high carbon content most of it is introduced by gas carburizing methods after coining. The carburized piece may be heat treated, case hardened, or electroplated by conventional methods to secure the desired surface condition, hardness, and mechanical properties.

A good example of the parts produced is the gun sear, Fig. 3, which requires close dimensional tolerances, good mechanical properties and a surface hardness of C-48 to 53. The critical dimension between the two parallel surfaces was required to be 0.030 ± 0.001 in. Because of their irregular shape, it had been difficult to hold to this tolerance in conventionally machined pieces. However, it was maintained successfully in the powder metallury process.

The process schedule used in producing these pieces was as follows:

Powder Mix – Annealed electrolytic iron powder (–50 mesh) blended with 0.5% stearic acid, 0.05% carbon, and 0.63% ferromanganese.

Briquetting – Approximately 27 tons per sq. in. pressure, on Stokes R-4 mechanical press.

First Sinter – 2 hr. at 2000° F. in cracked ammonia atmosphere.

Lubrication – Thin soap film.

Coining – 72 tons per sq. in. pressure.

Carburizing and Equalizing – 8 hr. at 1850° F., in cracked ammonia-methane atmosphere in equilibrium with 0.8% carbon.

Machining – Conical-shaped hole and semicircular shape around hole machined.

Quenching – In oil, from 1500° F.

Tempering – 575 to 600° F.

This resulted in parts having a surface hardness of C-48 to 53 and a final density ratio of 98.4% or more. Carbon content was approximately 0.8% at the surface and approximately 0.1% in the center. The microstructure was typical of good wrought steel as is shown by the micrographs in Fig. 4. Sears were tested under actual firing conditions in a rifle for 20,000 rounds without failure or detectable wear. The estimated life expectancy of the weapon itself is 4500 rounds.

The bayonet butt plate shown in Fig. 3 is costly to fabricate by conventional machining methods because of the rectangular hole, the T-shaped slot, and the elliptic contour. It has been machined from bar stock or forgings, hardened and tempered to Rockwell C-33 to 38. The requirements can be met by Class A steel compacts. The processing steps used were as follows:

Powder Mix – Annealed electrolytic iron powder (–100 mesh) blended with 1% stearic acid and 0.9% manganese.

Briquetting – 33 tons per sq. in. pressure.

First Sinter – 3 hr. at 2000° F. in dry hydrogen.

Lubrication – Thin film of stearic acid.

Coining – 100 tons per sq. in. pressure.

Anneal – 1 hr. at 1000° F. in dry hydrogen.

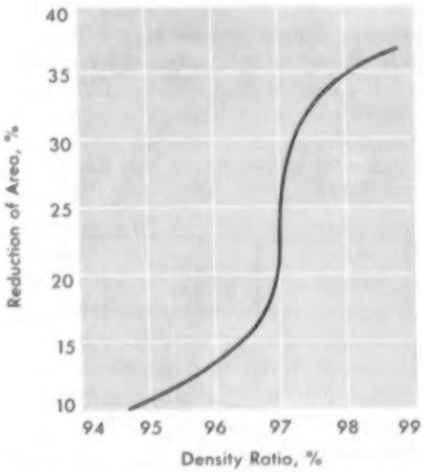


Fig. 2 – Relation Between Reduction of Area in Tensile Test and Density Ratio Showing Abrupt Improvement at About 97%

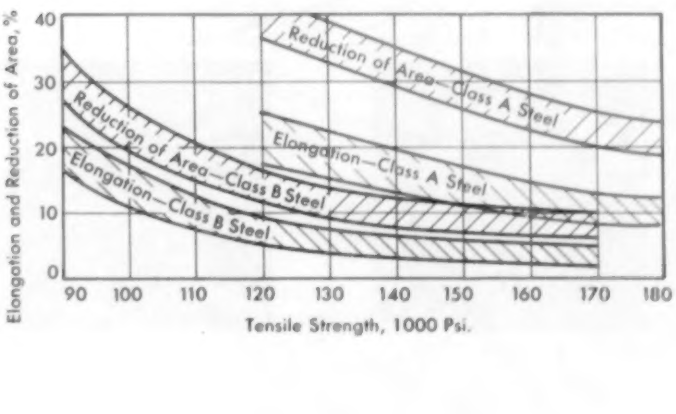


Fig. 1 – Mechanical Properties of Powder-Metallurgy Steels. Class A steel (color bands) corresponds to S.A.E. 1080; Class B is similar to S.A.E. 1060

Fig. 3 – Gun Sear (Right) and Bayonet Butt Plate (About Three-Quarters Size)

Machining – Mill side slots, drill hole, broach the tips.

Carburizing – 8 hr. at 1700° F. in hydrogen-propane mixture.

Equalizing – 14 hr. at 1700° F. in hydrogen-methane mixture.

Quench – In oil, from 1550° F.

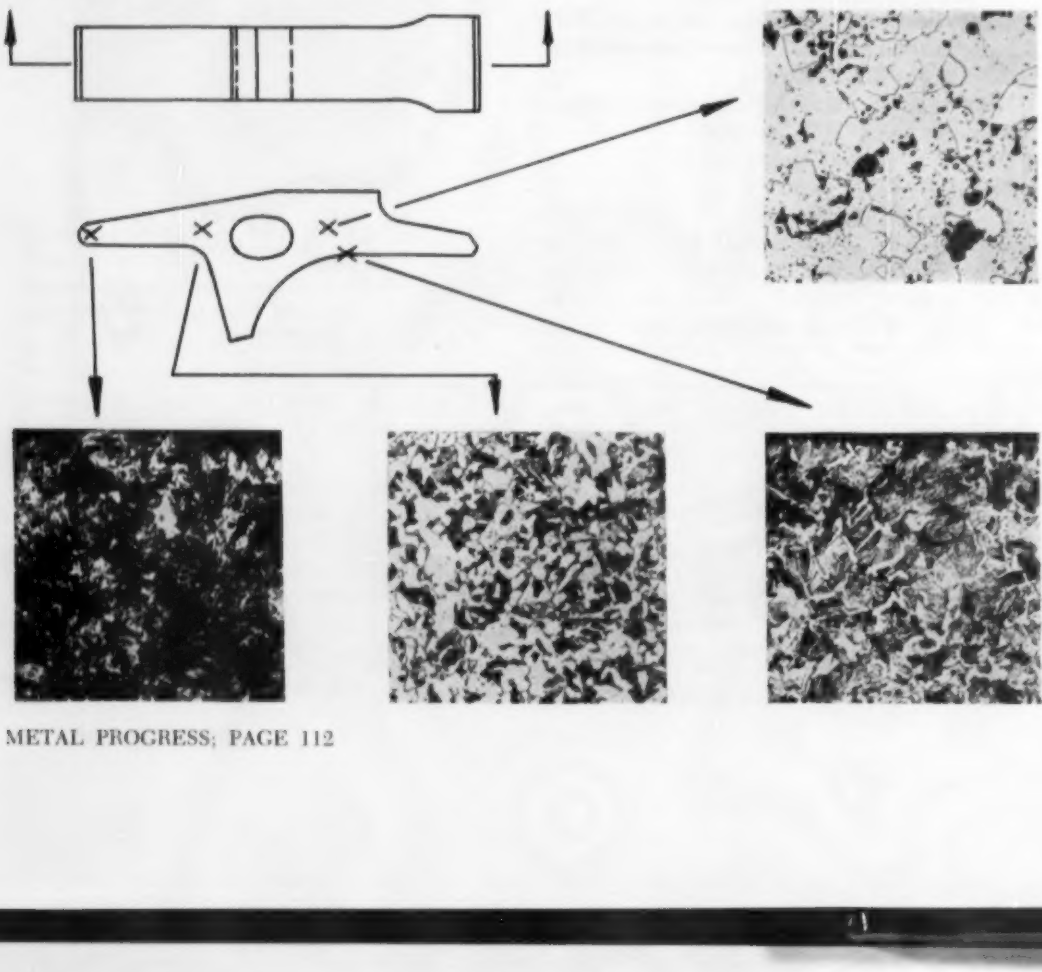
Temper – ½ hr. at 900 to 925° F.

The powder metal parts had a surface of C-33 to 38 and a density ratio of at least 98%. They were given simulated service tests and passed successfully. They were also tested by inserting a T-shaped bar in the T-slot and another bar in the rectangular hole, and applying tensile stress until the parts ruptured at the T-slot. They showed 50% higher strength in this test than pieces made from steel forgings. This was due not to higher strength of the powder parts, but rather to the fact that they had fillets in corners of the T-slot which were smoother and more perfectly formed than in the forgings. This illustrates a common advantage of powder metal parts over machined parts.

To obtain high density it is necessary that the iron powder should be annealed soft, contain not over 0.3 to 0.5% of alloying elements (excluding carbon, which should be less than 0.15%), and undissolved inclusions less than 1% by volume. Annealed electrolytic iron powder fulfills these requirements. Some manganese is added to secure good heat treating properties in the final part. This is done by the inclusion of a small percentage of ferromanganese powder in the initial powder mixture.

When a compact of iron powder containing ferromanganese is sintered, the manganese becomes oxidized as a result of oxygen and water which are always present. The manganese oxides remain undissolved and have a harmful rather than a beneficial effect. To avoid this, powdered graphite is included in the powder mixture, the

Fig. 4 – Microstructure of the Carburized Powder Metal Gun Sear. 100 ×



amount being determined by the oxygen present and the desired carbon content of the core of the compact after sintering. During sintering, this graphite prevents oxidation of the manganese, part of the graphite being removed from the compact in so doing. In making Class A steel the carbon content of the core of the compact is reduced to about 0.1% during sintering which leaves the compacts soft enough to be re-pressed easily to density ratios of over 97% at pressures of 60 to 80 tons per sq. in.

When it is desirable to have more carbon in the core of pieces, particularly in larger sizes, extra carbon is used in the original powder mixture. After removal of a small amount of carbon during sintering, the desired amount of carbon (up to 0.60%) will remain in the core. Since more carbon in the iron increases its hardness, such pieces cannot then be re-pressed to as high density and do not have as good mechanical properties as Class A steel. Steel made in this way is called Class B steel and has the mechanical properties shown in the black curves of Fig. 1. It is particularly useful in making larger parts for which through-carburizing would take too long.

Extra carbon can also be introduced by gas carburizing after the re-pressing operation, all the way through in the case of small pieces, or as a case of predetermined carbon content for both small and larger pieces. Often parts need not be carburized long enough to produce a uniform carbon content throughout, since most parts require the hardness, wear resistance, and strength imparted by high carbon content only near their outside surfaces. In fact, one of the most useful modifications of the process is that in which enough carbon is used in the original powder mix to produce a tough low-carbon core, and after the second pressing, a thin case is obtained by carburizing and is hardened to produce a wear resistant surface.

Another of the requirements for getting the necessary high density ratio is that the pressures used in the two pressing operations should be within certain critical ranges. The pressure used in the first pressing operation should never be over 40 tons per sq. in. Higher pressures weaken rather than strengthen the final piece by causing cracks which cannot be healed in the subsequent sintering, coining and heat treating. The pressure used in the final pressing must be at least 60 tons per sq. in. in order to produce the required critical density ratio.

Friction between the compact and the die walls must be minimized in coining if a high density ratio is to be obtained. Before coining, the briquets contain a high percentage of interconnected porosity. If a penetrating lubricant were applied, its presence in the pores would prevent their being closed by coining and the density would be low. Isthmian has developed a method of applying a film of soap to the briquets in such a way that it does not penetrate the pores. The soap is dissolved in water and used to coat a quantity of pellets of the type which are used in barrel burnishing. After coating, the pellets are dried, leaving them covered with a thin film of dry soap. The briquets to be lubricated are then tumbled with the coated pellets and themselves coated with a thin film of soap. The pellets are chosen of such a shape and size that all the surfaces, including internal angles and holes of the briquet, receive a thorough coating.

After re-pressing, additional carbon is introduced into the pieces by gas carburizing. In the case of Class A steel practically all the carbon is introduced at this stage. In the Class B steel the core will contain its required carbon and additional carbon is introduced only as a high-carbon case. When the carbon is to be diffused all the way through the parts the total carburizing time can be minimized by first carburizing the parts in an atmosphere of high carburizing potential for approximately one-third of the total time, then reducing the carburizing potential to be in equilibrium with the desired carbon content of the parts.

All the operations in preparing the powder, compacting, sintering, and carburizing that are used in the Isthmian processes are done with standard equipment which is commercially available. The briquetting operation is performed on conventional mechanical powder presses. The coining is done on hydraulic presses because they can be adjusted for a predetermined pressure rather than for a predetermined length of stroke. The carburizing requires a gas furnace equipped with a carburizing-potential sensing element and automatic control of the carburizing potential of the furnace atmosphere.

Carbide die-cavity inserts are used in the coining dies, and show no wear or abrasion after long runs. Steel dies may sometimes be used for briquetting, but carbide inserts are preferred, particularly for long runs. For most parts, separate die-and-punch sets are required for the first and second pressing operations. Both dies of a set are made to ordinary diemaking tolerances, yet can produce finished parts with uniform high density ratio over the entire part.

Effect of Neutron Radiation on Aluminum Alloys

*By R. V. STEELE and W. P. WALLACE**

The tensile strength and yield strength of aluminum alloys were increased by neutron irradiation. Ductility of annealed samples was decreased but not as much as if the same increase in strength had been obtained by heat treatment or mechanical means. (Q23, Al)

The effect of neutron radiation on the mechanical properties of metals is of interest to those who are engaged in the design, construction or operation of nuclear reactors and accelerators. Unfortunately, little information is available and much of it is based upon single or, at most, only a few specimens.

To obtain accurate information on the behavior of aluminum alloys, 224 specimens were prepared from three alloys, in two conditions or tempers for each alloy, and one temper for an additional alloy. Eight specimens from each alloy condition or temper were picked at random for control purposes; the 24 remaining samples from each alloy condition or temper were irradiated. All specimens for each alloy were machined from the same sheet. Table I lists the alloys used.

For irradiation the samples were inserted in the Materials Testing Reactor at Arco, Idaho, for a total neutron irradiation of 1.26×10^{21} neutrons per sq.cm. with an estimated fast neutron exposure of about 1×10^{20} neutrons per sq.cm. Specimens were water-cooled during

*Mr. Steele is now with Pratt & Whitney Aircraft Co., University of California Radiation Laboratory, Livermore; Mr. Wallace is with Hanford Atomic Operations, General Electric Co., Richland, Wash.

Typical Stress-Strain Curves for Alloy 1100 (2 S) Which Illustrate the Effect of Neutron Irradiation on the Properties of Annealed and Strain Hardened Material

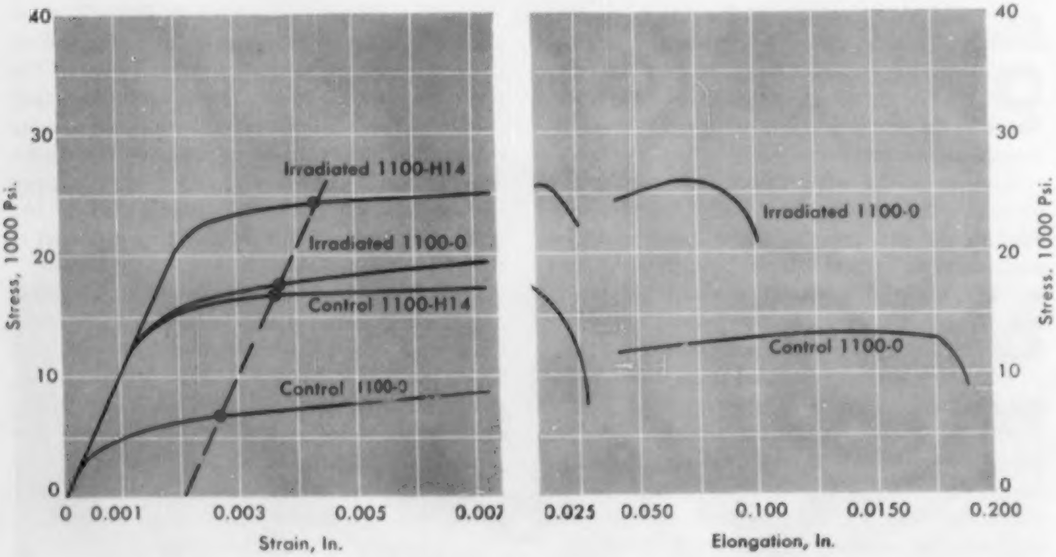


Table I – Alloys Used for Neutron Irradiation Tests

Material*	Temper	Nominal Composition, %						
		Mg	Cu	Cr	Fe	Mn	Zn	Others
1100 (2 S)	O—annealed H 14—Strain hardened (half-hard)	—	0.20	—	1.0	0.10	0.10	0.15
5052 (52 S)	O—annealed H 34—strain hardened and stabilized (half-hard)	2.50	0.10	0.25	0.45	0.10	0.10	0.15
6061 (61 S)	O—annealed T 6—Solution annealed and aged	1.00	0.27	0.35	0.70	0.15	0.20	0.15†
5154 (A 54 S)	Cold reduced 50% in thickness	3.50	0.10	0.25	0.50	0.10	0.10	0.15

*The first three specimens were 0.032 × 0.250 × 0.500-in. gage length; 5154 specimens were 0.062 in. thick.
†Also includes 0.60% Si and 0.15% Ti.

irradiation and the temperature of the specimens was estimated to be approximately 150° F.

They were positioned so that any effect due to temperature variation or flux distribution would affect all alloys approximately an equal amount. A notching system was devised to identify each specimen's position vertically and horizontally relative to the entire test assembly. The statistical variation of the test results and the variation in radioactivity of each alloy indicated that any effect produced by thermal gradients or by flux perturbations was less than 4%. Since this error was well within the statistical variations expected in testing any particular alloy, the thermal and flux gradients were assumed to be within 4% over the tested section.

The irradiation specimens were unloaded from the sample container in Livermore Research Laboratory "hot" cells. All were checked for dimensions before and after irradiation. Strain gages of the SR-4, A-8 type were bonded to all of the control and irradiated specimens prior to tensile testing.

A Baldwin SR-4 strain indicator was used to obtain a continuous record of strain within the limits of the gages. The straining rate for all tests was 0.010 in. per min. After rupture the over-all extension of the samples was measured and recorded. The data for the mechanical properties are summarized in Table II.

Both tensile strength and yield strength were increased significantly by the neutron irradiation; for 1100-O (2 S-O) and 6061-O (61 S-O), yield strength was almost tripled and tensile strength doubled by the exposure. For annealed material, elongation values were reduced but the ductility was greater in alloys strengthened by radiation than is obtainable in the alloy strengthened by strain hardening to the same level. For example, the tensile values of irradiated 5052-O (annealed) are 37,400 psi. tensile strength and 30.6% elongation; strain hardened 5052-H 34 has 36,000 psi. tensile strength and 11.2% elongation. The ductility of alloys previously hardened by either heat treatment or mechanical means either showed a very small loss or actually increased in value after exposure.

Table II – Summary of Test Results

Material	Condition	Number of Tests	Yield Strength Psi.	Tensile Strength Psi.	Elongation %
1100-O	Control specimens	8	6,800 ± 180	13,600 ± 320	38.2 ± 3.2
	Irridated specimens	25	17,100 ± 890	26,000 ± 2000	21.2 ± 1.2
1100-H 14	Control specimens	8	16,600 ± 250	17,300 ± 460	6.0 ± 0.6
	Irridated specimens	22	24,000 ± 450	26,000 ± 380	5.5 ± 1.2
5052-	Control specimens	7	14,700 ± 670	29,200 ± 450	34.0 ± 3.4
	Irridated specimens	22	22,900 ± 540	37,400 ± 490	30.6 ± 4.2
5052-H 34	Control specimens	7	29,500 ± 800	36,000 ± 700	11.2 ± 2.3
	Irridated specimens	21	36,400 + 1000	44,700 + 1200	14.0 ± 1.1
6061-O	Control specimens	8	9,460 ± 200	18,050 ± 240	28.8 ± 2.8
	Irridated specimens	25	25,600 ± 460	37,300 ± 400	22.4 ± 0.8
6061-T 6	Control specimens	8	38,500 ± 740	45,000 ± 320	17.5 ± 1.0
	Irridated specimens	23	44,400 ± 670	50,600 ± 540	16.2 ± 0.7
5154	Control specimens	8	47,800 ± 450	54,700 ± 500	8.8 ± 1.1
	Irridated specimens	17	50,800 ± 460	57,800 ± 510	12.5 ± 0.6

Automation in Welding Rod Manufacture

*By E. C. WRIGHT**

With only 25 men per shift, the new Westinghouse Electric Corp. welding electrode plant can produce almost 50,000,000 lb. of electrodes annually. Automatic equipment is used throughout and the unusual overhead construction of baking ovens saves floor space. (T5)

With a total labor force of less than 25 men in each shift, the new welding electrode plant of Westinghouse Electric Corp. in Montevallo, Ala., can produce almost 50,000,000 lb. of electrodes annually, 10% of estimated national consumption. The operation from unloading hot rolled wire coils from incoming cars through to packing is almost entirely automatic and most of the only labor required is for adjustment of machines and ovens and for maintenance.

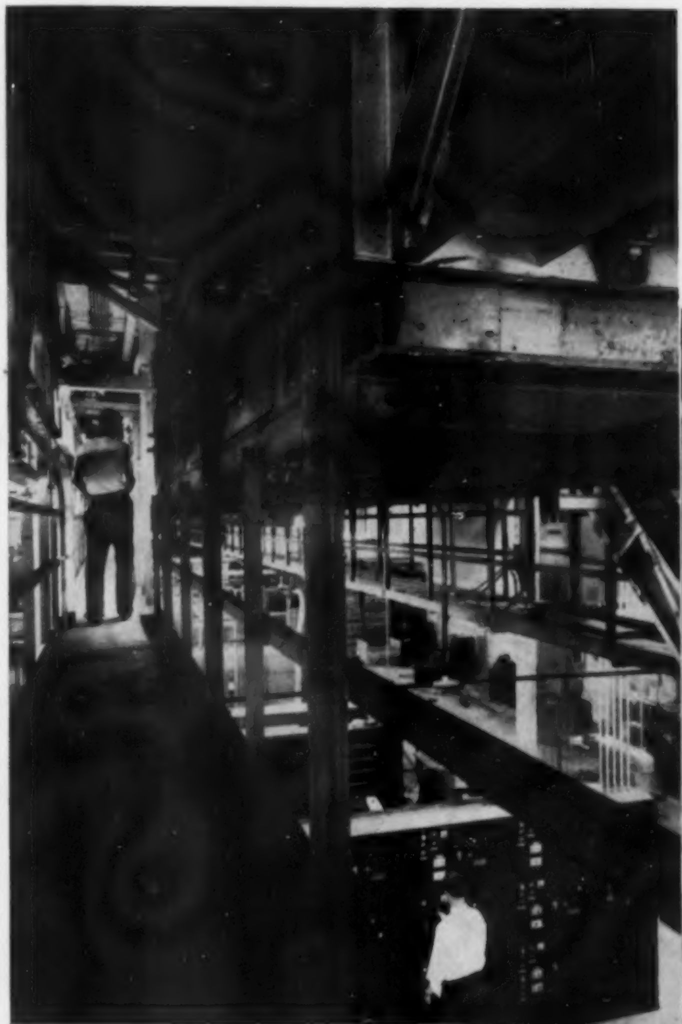
The welding electrode wire is obtained from steel mills in Birmingham in carload lots, hot finished and unpickled. Most of it is furnished in the standard rod size of 0.234 in. in coils. Special wire sizes are ordered for electrodes of larger diameter. The wire is run through a mechanical descaling machine which eliminates all pickling operations by passing it through a series of rolls that bend the wire to 90° in three different planes, thus cracking and loosening the mill scale. The wire is then passed through buffing brushes to remove the loose scale.

The clean wire is lubricated and cold drawn to size. Two draw blocks, with several spindles each, are sufficient for the daily requirements. The hot rolled wire from the coils is threaded through the descaling, lubricating and drawing blocks continuously.

Coils of drawn wire are next transferred to rod cutting machines where the wire is straightened, sheared and automatically stacked for the next operation. A very clean cut, free of burrs, is made on these machines. Cut rods are carried by conveyer to the flux coating section.

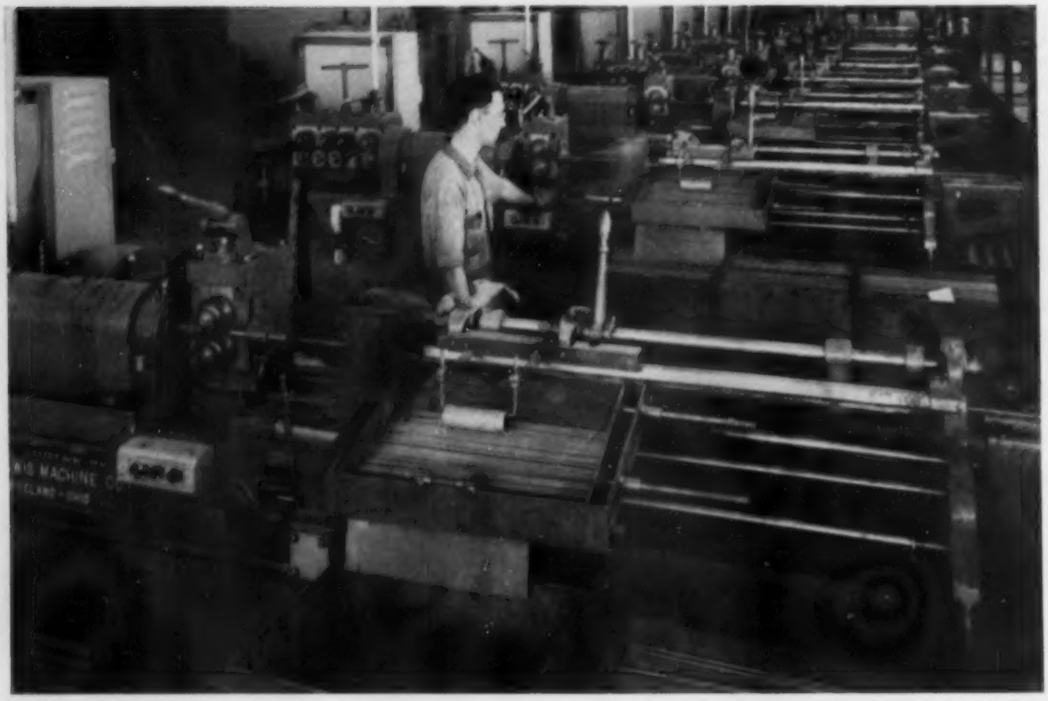
The chemicals used to compound flux mixtures are stored in carload lots in the back end of the plant. Proper ingredients are charged into one of two mulling machines, where water is added to temper the mix. The mix is mulled for several minutes to a stiff consistency and then pressed into cylindrical slugs about 18 in. long and 10 in. in diameter. These molded slugs are then ready for the cartridge chamber of the extrusion press, of which there are two. The cut rods are fed into the coating die at a rate of 1000 per min., coated to uniform thickness with extruded flux and ejected onto another conveyer. This conveyer passes through a brushing machine where the coating is removed from one end of

*Professor of Metallurgical Engineering, University of Alabama, University, Ala.; Consulting Editor for *Metal Progress*.



Section of the 450-Ft. Oven Used to Cure Electrode Coatings at Temperatures Ranging From 300 to 750° F. Baking time is 30 min.

Flow of Flux-Coated Electrodes, 1000 per Min., Into 450-Ft. Baking Oven Located 30 Ft. Above Floor Level



Bank of Ten Machines Where Coils of Wire Are Straightened and Cut to Proper Size for Use as Welding Rods

the rod — and then continues through one of the baking ovens to the scales on the packing floor. The rods are weighed and packed in an automatic machine.

The baking ovens are of unusual construction; one is 250 ft., and the other 450 ft. long; both are located 30 ft. above the plant floor on cross girders, and thus occupy no valuable floor space. They are heated by natural gas; automatic temperature control is by resistance pyrometers. Baking temperature for the carbon steel rods varies from 300 to 400° F. depending on the coating; for stainless steel rods, it may be as high as 750° F.

All of the electrodes of the American Welding Society's 6000 series are made from the same low-carbon manganese steel. Properties of deposited metal and welding characteristics of the rods are controlled by the composition of the coating. For example, E 6010 is high in cellulose plus sodium compounds; E 6011 replaces the sodium with potassium compounds. E 6012 and E 6013 substitute titania for the cellulose. E 6020's coating is high in iron oxide. Modified E 6013 and E 6020 have iron powder incorporated in the coating.

Coatings in A.W.S. 7010 and 7011 rod are similar to E 6010 and E 6011. 7020 has a high iron oxide coating, and 7016 rod has a lime-titania mixture.

Stainless steel electrodes are made by practices similar to carbon steel rods. Different drawing lubricants are necessary, however, and characteristic lime or lime-titania coatings are applied.

At the opposite end of the plant rods for nonferrous brazing are produced separately, since they have no flux coating, but are used with special fluxes brushed on the work. Two types of brazing rods are being produced: (a) copper-phosphorus alloy and *(b)* a copper-silver-phosphorus alloy. The alloys are received in the form of cast slugs, approximately 2 in. in diameter and about 5 in. long. These slugs are heated to a forging temperature of 1100° F. in a small gas-fired rotary furnace and then passed to a press which extrudes the various sizes required. Hot rods leaving the press are quenched in water, wiped to remove the oxide scale, and coiled. Coils are then taken to a straightening and cutting machine, weighed and packed for shipment. Only three men are necessary to operate this part of the plant.

Personal Mention

Arthur R. Lytle

Harry B. Osborn, Jr.

ARTHUR R. LYTLE has been appointed vice-president in charge of research for Electro Metallurgical Co., a division of Union Carbide and Carbon Corp., in New York, succeeding A. B. KINZEL. Mr. Lytle has been associated with the Corporation since 1923 when he joined the research laboratories at Niagara Falls, N.Y. In 1946 he became head of the welding department there and was subsequently appointed assistant manager of research. In 1952 he moved to the New York office to occupy the post of director of research for Electro Metallurgical Co. For the last two years of his connection with the Union Carbide laboratories, he was responsible for all the metallurgical research activities at that point. Before then he carried out and directed extensive research on the welding of metals. He developed many new welding rod compositions, including the first nonfuming bronze. Mr. Lytle also pioneered in the field of automatic welding machines, and was responsible for many advances in the use of the oxyacetylene flame for hardening, powder-cutting, and pressure welding processes. Mr. Lytle was born in Troy, N.Y., and was graduated from Rensselaer Polytechnic Institute as a chemical engineer in 1923. He is a member of the American Institute of Mining and Metallurgical Engineers and the American Welding Society.

HARRY B. OSBORN, JR. has been elected national president of the American Society of Tool Engineers for the year 1955-56. Dr. Osborn is technical director of the Tocco Div. of Ohio Crankshaft Co., Cleveland, a position to which he was appointed in 1948. He joined the Division in 1939 as research and development engineer, in 1940 assumed charge of sales development and research, was named director of research in 1942, and in 1946 was promoted to sales manager. He graduated from Lehigh University with a B.S. degree in engineering, and received the Master of Science degree in 1934. From 1934 to 1939 he served on the faculty of Lehigh University in the engineering department, and in 1937 received his Ph.D. degree. Dr. Osborn is the holder of many patents, author of a number of technical papers and publications on induction heating, and delivers an average of 35 talks yearly before the various technical societies in the United States and Canada. Extremely active in community affairs, he has received two local "Man of the Year" awards. Dr. Osborn is a member of several national defense committees, a past president of the Cleveland Technical Societies Council, past chairman of the Cleveland Section of the Electrochemical Society and a past chairman of the Cleveland Chapter of A.S.T.E.

John Parina, Jr., for the past four years associate editor of *Metal Progress*, has been appointed associate editor of the Metals Handbook. In his new position, Mr. Parina is currently preparing for publication the articles submitted by 11 of the 25 A.S.M. technical committees that were organized during the latter part of 1954.

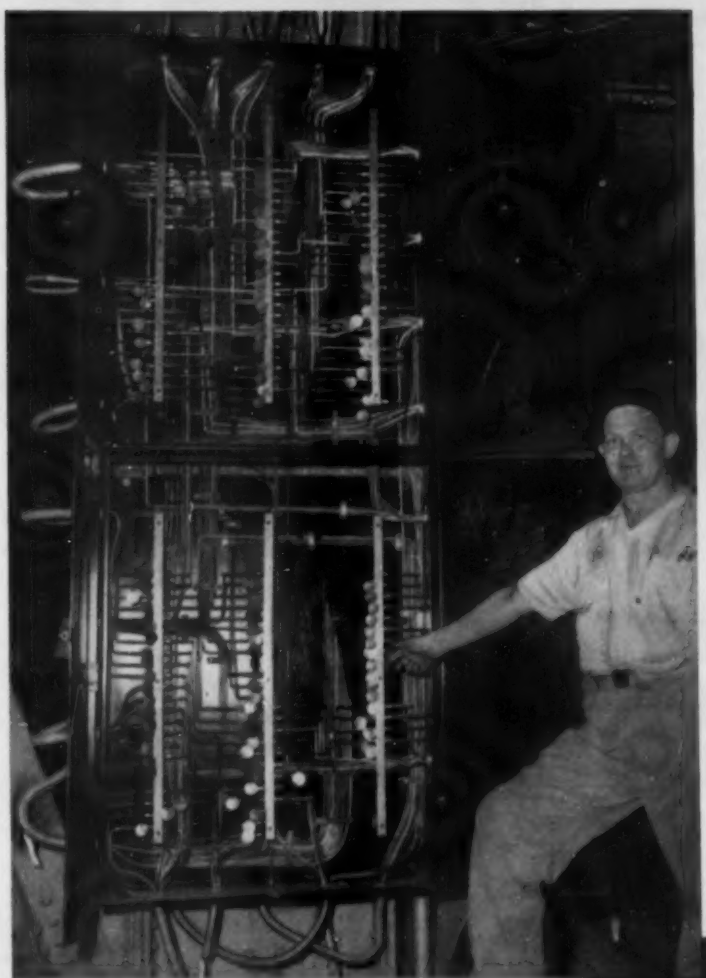
Mr. Parina came to A.S.M. from Baker-Raulang Co. in 1951. His experience includes eight years in production and engineering work at American Steel & Wire Co., technical editorial staff of *Steel* magazine, advertising work with Warner & Swasey Co., sales promotion and advertising manager for Star Drilling Machine Co., and sales engineer at Baker-Raulang.

A. F. Davis, vice-president and secretary of the Lincoln Electric Co., Cleveland, was among the first recipients of a new award established by the Ohio State University to pay highest tribute to its outstanding engineering alumni. The first "Distinguished Alumnus" awards were made by the University before 800 persons attending the Second Annual Engineering Conference for Engineers and Architects held in Columbus on May 6. Mr. Davis, selected by vote of the college faculty to receive the award, was cited for his "outstanding attainments as an industrial executive, sales and advertising genius, civic leader and a graduate engineer who fulfills his responsibility to education to the highest degree". Mr. Davis received the degree of M.E. in electrical engineering in 1914 at the Ohio State University and joined the Lincoln Electric Co. following graduation. He is also secretary of the James F. Lincoln Arc Welding Foundation.

Howard H. Casey has been elected vice-president in charge of sales of the Midvale Co., Philadelphia. Joining the company in June 1952 as general manager of sales, Mr. Casey was appointed director of sales and engineering in December 1954. He will continue his duties as director of engineering. He is a graduate of Drexel Institute of Technology, and spent 29 years with Camden Forge Co., Camden, N.J. prior to joining Midvale.

FOR INSTRUMENTATION AND CONTROL

Cabled Tube



Some time ago Revere ran an advertisement featuring Crescent Armored Multitube for use in pneumatic and hydraulic instrumentation and control systems. The advertisement created so much interest that we thought you might like to see a photograph of an actual installation. The Control Board Junction Box shown here has 22 runs of Multitube coming into this box comprising 224 Revere Copper Tubes of 1/4" O.D. The picture was taken in the Glenwood Landing, N.Y. Power Station of the Long Island Lighting Company. The tubes go to instruments that report information on temperature, main and reheat steam pressure, boiler feed and condensate pump pressure, fuel oil and gas pressure, liquid levels, tide level and for the control of fuel feed, draft dampers, boiler drum water level and various control valves.

This is a relatively new use for Revere Copper Tube, but it is an important one in these days when new ways are being found to obtain process information more quickly and accurately, or to achieve automatic control. Crescent Armored Multitube is made by Crescent Insulated Wire & Cable Co., Inc., Trenton 5, N.J., in lengths up to 1,000 feet. It consists of a group of long tubes twisted together in cable form, protected by a flexible interlocked galvanized steel armor, or by plastic, or both. As many as 19 tubes, 1/4" O.D., can be cabled, with one tube in each layer color-coded. Larger tubes can also be cabled, including 5/16", 3/8" and 1/2". This construction affords protection during shipment, installation and use, and speeds up installation greatly. For further information, write Crescent, and for tube in copper and aluminum, see the nearest Revere Sales Office.

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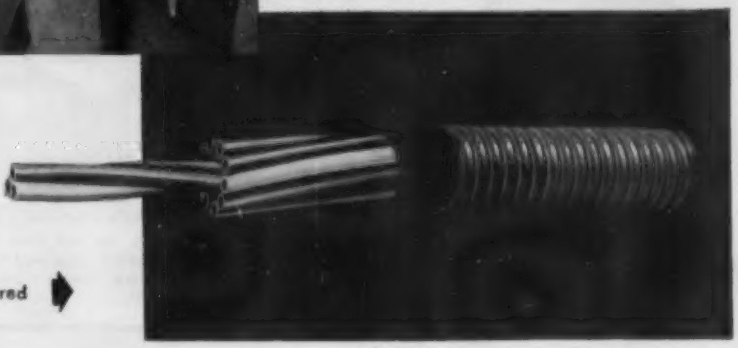
Control Junction Box at Power Station of Long Island Lighting Company, showing use of Crescent Armored Multitube. Note that relatively sharp bends can be made without damage to the cabled copper tube.



Construction of Crescent Armored Multitube.

Personals . . .

Claude H. Leland has been appointed assistant chief engineer of the Industrial Heating Equipment Co., Detroit.

William H. Graves, Jr. has been elected vice-president and director of engineering of Studebaker-Packard Corp., Detroit. Mr. Graves was formerly executive engineer at Packard Motor Car Co.

James R. Long, formerly on the Metallurgical Advisory Board, National Academy of Sciences, Washington, D.C., is now a metallurgist for Harvey Machine Co., Torrance, Calif.

W. A. Reinsch has resigned from the engineering department at Chance Vought Aircraft, Dallas, Tex., to join the research department of North American Aviation, Inc., Los Angeles, as a senior research engineer.

A. H. Barton resigned his position as metallurgist for Kahr Bearing Div., Aetna Steel Products Corp., Burbank, Calif., to rejoin the truck engine works, International Harvester Co., Indianapolis, Ind., where he holds the position of assistant foundry metallurgist.

Harry L. Edgcomb, formerly vice-president in charge of sales, is now president of Edgcomb Steel and Aluminum Corp., Hillside, N.J.

Augustus B. Kinzel has been elected vice-president in charge of research of Union Carbide and Carbon Corp., New York. Dr. Kinzel has been actively engaged in research work with Union Carbide and Carbon Corp. since 1926, when he joined Electro Metallurgical Co. as a research metallurgist. He became chief metallurgist of the laboratories in 1931, and a vice-president of Electro Metallurgical Co. in 1944. He was appointed director of research of Union Carbide and Carbon in 1954. (A biographical appreciation of Dr. Kinzel appeared in *Metal Progress* in August 1953.)

Robert Maddin, associate professor of metallurgy at the Johns Hopkins University, has been appointed professor of metallurgy in the School of Metallurgical Engineering, University of Pennsylvania, beginning July 1955. Dr. Maddin was visiting lecturer in metallurgy at the University of Birmingham, England, for 1954, returning to his post at Johns Hopkins last February.

Childress B. Gwyn, Jr. joined the general plate division of Metals and Controls Corp., Attleboro, Mass., in May. Mr. Gwyn's many years of experience in the metallurgical and electrical contact field began with Delco Remy Div. of General Motors Corp., Anderson, Ind., continuing for approximately six years as chief engineer, the position he also held successively with P. R. Mallory, Indianapolis, Ind., and Fansteel Metallurgical Corp., North Chicago, Ill. He spent the following ten years as general manager, tungsten-sintered metal division, H. A. Wilson Co., Newark, N.J.

Norman L. Deuble has had his title changed by Climax Molybdenum Co., New York, from manager of metallic molybdenum sales to manager of the newly created metallurgical development division. Since joining Climax Molybdenum in 1947, Mr. Deuble has won wide recognition as an authority on the development of metallic molybdenum produced by the arc-casting process, and has worked closely with users of these materials in the electronics and high-temperature fields. He graduated from Case Institute of Technology in 1920, and is author of the current series on arc-cast molybdenum (see p. 105).

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Charlotte†	Denver	Kansas City, Mo.	New Orleans	Rochester†	(†sales office only)

Personals . . .

Maurice J. Day ⊕, director of research and development at Crucible Steel Co. of America, Pittsburgh, was one of eight outstanding American engineers to receive a special Centennial Citation and Award from Michigan State College recently. The awards were given "for outstanding contributions to society, for achieving distinction in their endeavors, and for setting the highest standards of accomplishment". Dr. Day was honored specifically "for his years of service in the field of metallurgical research and development" and for his "distinguished contributions both to the theory and the practice of metallurgy". The citation also honored Dr. Day for his work on important professional national committees, of which he is either chairman or member, and for his service in civic and non-occupational organizations.

W. Roy Willard ⊕ has been appointed assistant to the president of Buffalo Steel Corp., Tonawanda, N. Y., after 18 years with Republic Steel Corp., Cleveland, where he was employed in the operating, metallurgical, and sales departments. Mr. Willard graduated from Case Institute of Technology in 1937.

William E. Liesman ⊕ has been appointed assistant sales manager of the Parish Pressed Steel Div., Dana Corp., Toledo, Ohio. Mr. Liesman joined the organization in the metallurgical laboratory in 1946, transferring to the sales department in 1947. He is a graduate of Lehigh University with a B.S. degree in metallurgical engineering.

Frank W. Glaser ⊕ has been appointed vice-president and director of Alloy Precision Castings Co., Cleveland, and is in charge of new development work, engineering and production operations. A graduate of City College of New York and Polytechnic Institute of Brooklyn, Mr. Glaser was formerly vice-president in charge of research and development for the American Electrometal Corp., Yonkers, N.Y. He also conducted some of the pilot plant operations for the Borolite Corp., Niagara Falls, N.Y., and was a director of the firm. Mr. Glaser is the author of "Progress Report on Cermets" in the April 1955 issue.

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Personals . . .

A. O. Schaefer, national vice-president, has been re-elected vice-president in charge of engineering and manufacturing of the Midvale Co., Philadelphia.

S. B. Knutson has been appointed plant manager in charge of all production operations at Kidd Drawn Steel Co., Aliquippa, Pa. Mr. Knutson, a graduate of the University of Minnesota, was formerly superintendent of the Flex Steel Div., National Electric Products Corp., Pittsburgh. At the same time, **T. S. Palmquist** was appointed director of engineering and development for Kidd Drawn, and **Alexander H. Gaal**, a former vice-president of Earle M. Jorgenson Co., Los Angeles, has been appointed sales representative in the California, Arizona and Nevada area with headquarters at Pasadena, Calif.

Eugene H. Kinelski has joined the development and research division of the International Nickel Co., Inc., as a research metallurgist in the welding section of the research laboratory at Bayonne, N.J. Mr. Kinelski graduated from Purdue University in 1942 with a B.S. degree in metallurgical engineering and took graduate study in metallurgy at Purdue and the University of Pittsburgh. He helped to develop a ram-jet propulsion unit at the Applied Physics Laboratory of Johns Hopkins University, engaged in metallurgical research at Cornell Aeronautical Laboratory, taught metallurgy at Purdue University Calumet Center, and headed a fellowship at Mellon Institute. Before joining International Nickel, Mr. Kinelski was associated with Inland Steel Co., Pullman-Standard Car Mfg. Co., and Sintering Machinery Corp.

W. H. Humphries, Jr., formerly assistant superintendent, blast furnaces, is now sales engineer, Neville Coke Div., Pittsburgh Coke & Chemical Co., Pittsburgh.

Robert W. Devine, Jr., who has been research metallurgist with the steel and tube division of the Timken Roller Bearing Co., Canton, Ohio, since graduating from Massachusetts Institute of Technology eight years ago, is now a junior security analyst, Wertheim & Co., New York City.

Personals . . .

William J. Harris has been appointed assistant to the director of Battelle Memorial Institute, with headquarters in the Washington, D. C. office. He will represent Battelle in its relationship with the numerous governmental organizations that sponsor research in the laboratories of the Institute. Prior to joining Battelle a year ago, Dr. Harris served for three years as executive secretary of the Minerals and Metals Advisory Board of the National Academy of Science and the National Research Council. Before that, he was head of the Ferrous Alloys Branch of the Metallurgy Division, Naval Research Laboratory at Washington. During World War II he served on active duty as head of the Navy's Bureau of Aeronautics' Aircraft Armor Section. In 1950 Dr. Harris was the corecipient of the Matheson Medal presented by the Institute of Medals Division of the A.I.M.E. Dr. Harris received his B.S. in chemical engineering and M.S. in metallurgy from Purdue University. He was awarded a Rockefeller Foundation pre-doctoral fellowship and in 1948 received his Ph.D. in metallurgy from Massachusetts Institute of Technology.

Ernest F. Nippes, director of welding research at Rensselaer Polytechnic Institute, has been authorized by the Carbide and Carbon Chemical Co. to extend the program of research he has been conducting for the Oak Ridge National Laboratory since Sept. 1, 1951. The laboratory is operated by the company, a division of Union Carbide and Carbon Corp., for the U. S. Atomic Energy Commission. Under the contract of the sponsoring company with the Institute, Dr. Nippes and his associates are investigating the flash welding of molybdenum.

Ernest C. Schleusener was recently elected vice-president in charge of manufacturing, a newly created office at Mueller Brass Co., Port Huron, Mich. Mr. Schleusener was formerly works manager for the same company.

C. E. Overly has been appointed sales engineering representative for Aurora Metal Co., Aurora, Ill., to cover the Pittsburgh-Youngstown, Ohio, area.

Personals . . .

George H. Thurston ⊕ has been appointed representative of Ajax Electric Co. for the San Francisco-Northern California area.

Frank M. Levy ⊕, formerly director of research, has been promoted to the newly created office of vice-president in charge of research at Mueller Brass Co., Port Huron, Mich.

Henry S. Schaufus ⊕ has been appointed chief metallurgical engineer of Vanadium Corp. of America, New York. He has been associated with Crucible Steel Co. of America, Eastern Stainless Steel Corp., and Rustless Iron and Steel Corp. More recently, he has acted in a consultant capacity to the steel industry.

W. N. St. John ⊕, formerly engineering consultant, is now product manager for Silicone Rubber Products Div. and Hewitt Rubber Div. of Hewitt-Robins, Inc., Buffalo.

Ivor D. Thomas ⊕ is now a metallurgist with General Electric's product metallurgy unit, engineering department, at the Hanford atomic installation near Richland, Wash., which is operated for the U.S. Atomic Energy Commission. Dr. Thomas was formerly plant manager, Induction Steel Foundry Co., Salt Lake City, Utah. He is a graduate of the University of Utah, where he received his Ph.D. in metallurgy in 1951.

J. A. Succop ⊕, chief metallurgist of Heppenstall Co., Pittsburgh, was the recent recipient of the David Ford McFarland Award given by the Penn State Chapter ⊕. (See *Metals Review*, June 1955). Mr. Succop was graduated from Penn State College in 1917, and joined Heppenstall Co. two years later. He received a metallurgical engineering degree in 1920.

Frank S. Brewster ⊕ recently joined the staff of Brumley-Donaldson Co., Los Angeles, as foundry consultant. Mr. Brewster was formerly vice-president and general manager of Harry W. Dietert Co., Detroit, and most recently has been engaged in establishing a quality control program for South Gate Aluminum & Magnesium Co. in the Southern California plant.

720 Hours at 2300 Deg. F ...Didn't Hurt This Muffle

Continuous exposure at 2300 deg. F had little effect on a muffle made of HASTELLOY alloy X and used in this electric annealing furnace. The muffle was subjected to the intense heat for an entire month, 24 hours a day. After this extended service it was examined, found to be in excellent condition, and put back in service.

Actually, HASTELLOY alloy X solved a dual problem for this Company. The muffle is used in a furnace for annealing cold-drawn parts. Periodically, it is used for annealing superalloy parts at 2300 deg. F. Most of the time, however, it is used to anneal stainless steel parts at lower temperatures. Other materials were either inadequate for this service or too costly. Only HASTELLOY alloy X could handle both conditions economically.

HASTELLOY alloy X is a wrought high-temperature alloy with excellent strength and oxidation resistance to 2300 deg. F. For a copy of a booklet describing HASTELLOY alloy X, get in touch with the nearest sales office listed below.

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Personals . . .

Vaux H. Adams (ASM) has been appointed assistant district manager of Firth Sterling, Inc., in the Detroit territory.

S. M. Stoler (ASM) has been elected president of the R-S Furnace Co., Inc., Philadelphia.

Frank Kerze, Jr. (ASM), formerly principal metallurgist for the Bureau of Ships' Code "590" (Atomic Submarines) has resigned to accept a position with the Atomic Energy Commission as assistant to the director of reactor development. Mr. Kerze served on the chemical engineering and metallurgy staffs of Columbia University and New York University prior to going to the Oak Ridge National Laboratory in 1946 as senior chemical engineer. He left there in 1949 as section head, metallurgy division, to take the staff position in the Bureau of Ships.

Roy C. Raymond (ASM) has been promoted to the position of chief inspector for the Singer Mfg. Co., Bridgeport, Conn. Mr. Raymond is secretary of the New Haven Chapter of A.S.M.

William E. Mahin (ASM), formerly technical director of Vanadium Corp. of America, Cambridge, Ohio, has been appointed vice-president and director of research for the Hunter Engineering Co., Riverside, Calif. Before going with Vanadium, Mr. Mahin was director of research at Armour Research Foundation, Illinois Institute of Technology.

H. Maurice Banta (ASM) has been appointed technical adviser at Battelle Memorial Institute, Columbus, Ohio, and will advise clients in the iron, steel, and metal fabricating industries on the formation of their research programs. He will also continue his close association with technical studies of petroleum and gas drilling, production and drilling equipment, and pipeline installation and maintenance. Mr. Banta has directed metallurgical research at Battelle since 1942. Prior to that time he held research and production positions with the Central Alloy Steel Co. and the Jones and Laughlin Steel Corp. He is a Purdue graduate and author of numerous metallurgical papers.

Personals . . .

Arthur G. Metcalfe, research metallurgist, has been promoted to senior metallurgist, the highest professional position at Armour Research Foundation of Illinois Institute of Technology, Chicago. Dr. Metcalfe joined the Foundation as research metallurgist in 1953, after serving in the same capacity at the Deloro Smelting and Refining Co., Deloro, Ont., Canada. He holds B.A., M.A., and Ph.D. degrees from Cambridge University, England.

William O. Sweeny has been elected vice-president in charge of sales of Arwood Precision Casting Corp., Brooklyn, N.Y.

R. J. Severson, formerly manager of technical sales, Ampco Metal, Inc., Milwaukee, Wis., has been appointed assistant general sales manager. Mr. Severson, a graduate of the University of Detroit, has been with Ampco since 1943 and has served in various managerial capacities in both sales and production.

Richard A. Schaus has been appointed manager of induction and miscellaneous equipment engineering for the industrial heating department of General Electric Co., Schenectady. Mr. Schaus was recently engaged in reactor development at the Company's Knolls Atomic Power Laboratory. After graduation from the University of Michigan, where he received a B.S. degree in metallurgical engineering in 1938, he spent several years in technical sales with the United States Steel Corp. and in metallurgical research at Consolidated Vultee Aircraft before joining General Electric.

John H. Romann is now chairman of the board of directors of the Prescott Co., Menominee, Mich.

Donald C. Larson has been awarded the Metal Powder Association's first scholarship in powder metallurgy, which was established this year to encourage engineering students to specialize in powder metallurgy in order to help fill the need for trained personnel and to give the deserving student an opportunity to follow a pursuit with a promising future. Mr. Larson, now in his junior year, is majoring in metallurgy at the University of Washington.

Personals . . .

Robert L. Fullman, metallurgist at the General Electric Research Laboratory, Schenectady, N.Y., recently received the Yale Engineering Association's Award for Advancement of Basic and Applied Science which is given annually to a Yale alumnus out of college 15 years or less. Dr. Fullman, who recently was appointed manager of the materials and processes studies section at the G.E. Laboratory, received a B.E. degree from Yale in 1943 and D.Eng. in 1950. Dr. Fullman has been at the Research Laboratory since 1948, specializing in studies of recrystallization, grain growth, and the origin of metallic microstructures.

John J. Green, who has been associated with Universal-Cyclops Steel Corp., Bridgeville, Pa., for the past ten years, has been appointed service engineer in the Pittsburgh office of Vanadium Corp. of America. Mr. Green graduated from the Carnegie Institute of Technology as a metallurgical engineer in 1939 and has specialized in the study and application of stainless steels.

Lars E. Ekholm has been appointed manager of the sales division of Climax Molybdenum Co., New York. Mr. Ekholm, who received his degree as a metallurgical engineer from Lehigh University in 1929, has been associated with Climax Molybdenum since 1946, having held several executive positions in the sales department including the direction of foreign sales. He has also assisted in the development of important phases of the company's market research, sales promotion and advertising programs. Before joining Climax, Mr. Ekholm spent fifteen years with Alan Wood Steel Co., Conshohocken, Pa., where he served in the technical department as chief metallurgist and in the sales department in various sales and executive capacities.

John Bermingham, formerly sales representative for E. F. Houghton & Co., Philadelphia, has been appointed western sales manager with headquarters in San Francisco. Mr. Bermingham is the present chairman of the San Francisco Section of the American Foundrymen's Society and a past-chairman of the Golden Gate Chapter.

NATCO ENGINEERS

OVERCOME DISTORTION

DURING MACHINING

WITH

STRESSPROOF®

SEVERELY COLD-WORKED, FURNACE-TREATED STEEL BARS

The Lead Screw Tapper Spindles of this Natco Three-way Holetapper required machining operations hard to combine without serious distortion.

The front end of each spindle had to be machined as a taper socket for collet application. When the driving keyway and the tool knockout elongated-splined-holes were machined, distortion caused out-of-round taper holes which would not receive the collet correctly.

The rear end of each spindle had to be machined as a driving spline shaft which slides under load. Since the diameter of the spline is relatively small in proportion to the shaft length, any attempt to heat treat caused distortion hard to correct by straightening.

And at the center of each spindle, an accurate lead screw had to be machined by a thread grinding operation. It was found that the finish was much more easily obtained when STRESSPROOF was used.

STRESSPROOF eliminated both the problem of the out-of-round taper holes on the front of each spindle . . and the distortion of the driving-spline-shaft.

STRESSPROOF makes a better part at a lower cost.

National Automatic Tool Co. has for many years used STRESSPROOF in the manufacture of important operating parts for this Three-way Holetapper, as well as for other Natco high-speed machine tools.

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Helpful Data Bulletin No. 15 "Improve Quality —Cut Costs"

AVAILABLE FROM LEADING STEEL DISTRIBUTORS COAST-TO-COAST

La Salle STEEL CO.

1424 150th Street, Hammond, Indiana

MANUFACTURERS OF AMERICA'S MOST COMPLETE LINE OF QUALITY COLD-FINISHED STEEL BARS

Personals . . .

William L. Bruckart has been appointed sales engineer for Universal-Cyclops Steel Corp., Bridgeville, Pa. Mr. Bruckart was previously associated with Battelle Memorial Institute, Columbus, Ohio, where he served as assistant chief, nonferrous physical metallurgy division. He was graduated from the University of Kentucky with a B.S. degree in metallurgical engineering and received an M.S. from Ohio State University.

Philip K. Reardon is now a sales representative for Hawkridge Bros. Co., Boston, Mass., and Hawkridge-Waterbury Div., Waterbury, Conn., covering the state of Rhode Island and part of Connecticut.

Robert M. Stackhouse has resigned as metallurgist with the J. Bishop & Co. Platinum Works, Malvern, Pa., and is now employed at the atomic power division of Westinghouse Electric Corp., Pittsburgh.

Paul E. Chisler, formerly manager of technical sales, Tempil Corp., New York, has been appointed managing engineer, metals division, Surface Chemicals, Inc., Forbes Road, Pa., a subsidiary of the McKay Co., Pittsburgh. Mr. Chisler was formerly associated with Page Steel and Wire Div., American Chain and Cable, as plant metallurgist, and Ivy H. Smith Co., Jacksonville, Fla., as vice-president in charge of operations. He has been associated with the wire industry for 18 years.

David C. Williams, formerly of Crosley Div. of Avco Mfg. Co., New York, has been appointed general manager of the Danville Div., Tecumseh Products Co., Danville, Ill.

John R. Rink, employed as a metallurgical engineer in the aeronautical division of Minneapolis Honeywell Regulator Co., Minneapolis, Minn., before being drafted into the U. S. Army in February 1954, is now assigned as a research metallurgist in the Ballistics Research Laboratory, Aberdeen Proving Ground, Md.

Joseph R. Driear has resigned as process supervisor at the Savannah River Plant, Ga., E. I. du Pont de Nemours & Co., Inc., to accept the position of supervisor of the metallurgical laboratory of Eaton Mfg. Co., Detroit.

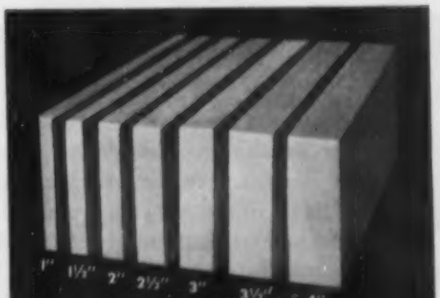
Specify J-M Superex, industry's favorite block insulation

Made from diatomaceous silica and asbestos for all temperatures to 1900F

YOU'LL ENJOY *greater insulation savings* with Superex®. Its unique combination of low conductivity and outstanding resistance to high temperatures provides greater operating efficiency and longer maintenance-free service. That's why Superex is the leading block insulation for furnace work.

Light and easy to work. Superex withstands temperatures to 1900F indefinitely with negligible loss of efficiency and is so strong that it compresses only ⅛ inch under 6 tons' pressure per square foot. Its light weight, excellent working properties and availability in large blocks mean quick, easy, low-cost installation.

For high temperature equipment. Since its introduction in 1927, Superex has received enthusiastic acceptance. Today it economically insulates 90% of the country's hot blast stoves. Other high temperature equipment where Superex has proved its superior performance include most types of industrial and metallurgical furnaces and ovens, stationary and marine boilers, regenerators, kilns, roasters, high-temperature mains, flues and stacks.



Saves waste—Superex comes in 7 standard thicknesses from 1" to 4". Other sizes available on order.

For further information on Superex, write to Johns-Manville, Box 60, New York 16, N. Y. In Canada, Port Credit, Ont.

JM JOHNS-MANVILLE PRODUCTS

Johns-Manville *first-in* **INSULATION**

MATERIALS · ENGINEERING · APPLICATION

Personals . . .

Eugene E. Lorenz was recently transferred from correspondent in sheet and plate products division, general sales office, Reynolds Metals Co., Louisville, Ky., to the divisional office in Atlanta, Ga., as sales representative.

Robert H. McCreery, for seven years principal metallurgist at International Harvester Co., Evansville, Ind., recently joined Warner Gear Div. of Borg-Warner Corp., Muncie, Ind., as metallurgist.

Frank W. LaHaye has resigned as chief engineer of Bennett Products Mfg. Co., Palo Alto, Calif., to join McCormick Selph Associates, Hollister, Calif., where he will be vice-president in charge of engineering and production.

James R. Hunt recently resigned as research engineer with North American Aviation, Inc., Inglewood, Calif., and is now a development engineer in the design division of the research department, Union Oil Co. of California.

Raymond B. Roof, Jr. received the degree of Ph.D. in crystallography from the University of Michigan in June and is now employed by Westinghouse Electric Corp., Pittsburgh, to do research in atomic power.

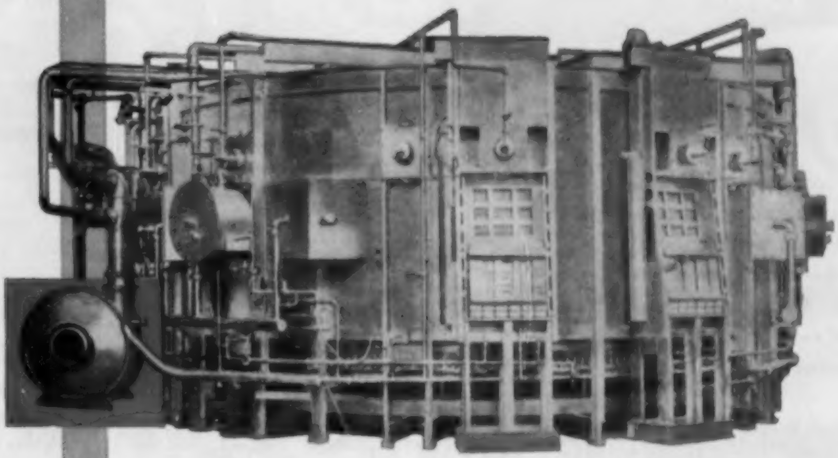
Sigmund L. Fredericks has been transferred by the American Steel Foundries from East St. Louis, Ill., where he was employed as process engineer, to the Indiana Harbor, Ind., works, where he is in charge of processing the new "Wearport" steel.

Wayne K. Minnich, is now stationed at Redstone Arsenal in Alabama as an instructor of electronics and radar at the Ordnance Guided Missile School of the U. S. Army. Private Minnich was formerly employed as a metallographer at the Aircraft Gas Turbine Div., General Electric Co., Cincinnati, Ohio.

Frank C. Perkins has recently accepted a position as research metallurgist with the Denver Research Institute, Denver, Colo.

Richard A. Kelly is now chief engineer for Flinn & Dreffein Engineering Co., Chicago.

Recuperative Hot Atmosphere System with—



SPENCER TURBO-COMPRESSORS

HARTFORD

by The LITHIUM COMPANY

111 SYLVAN AVENUE, NEWARK, N. J.

This 26 foot diameter Rotary Hearth Furnace heats billets, scale free, to forging temperatures, by means of the Lithium recuperative hot atmosphere system. Air for the direct gas-fired burners is supplied by a Spencer Turbo-Compressor.

In modern heat treating Spencer Turbos are operating 24 hours a day—on 7 day weeks with a maximum of reliability and efficiency. Reliability is insured by the wide clearances, all metal construction and only two bearings to lubricate.

Efficiency is insured by the Spencer design which uses power in proportion to the load.

Capacities from 8 oz. to 10 lbs., 35 to 20,000 cu. ft.
Ask for Bulletin No. 126.

THE SPENCER TURBINE COMPANY

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Manufacturers of Turbo-Compressors and Heavy Duty Vacuum Cleaners

Personals . . .

William D. Gilder, former chief metallurgist for the Weatherhead Co., Cleveland, has been appointed chief metallurgist for Reed Roller Bit Co., Houston, Tex.

R. L. Brady, former vice-president of Warwood Tool Co., Wheeling, W. Va., is coordinator of Aetna Steel Co., Jacksonville, Fla.

Byron W. Elder is now the Detroit resident service metallurgist for Pittsburgh Steel Co.

Vernon A. Sturm, former metallurgist and certifying engineer for the Thor Corp., Cicero, Ill., is now plant engineer and metallurgist with C. E. Robinson Co., Joliet, Ill.

Philip E. Schneider is now development metallurgist for Universal-Cyclops Steel Corp., Bridgeville, Pa. Mr. Schneider was previously a metallurgist with Armco Steel Corp. at the Baltimore, Md., works.

Eibe W. Deck is now vice-president in charge of manufacturing at the Lunkenheimer Co., Cincinnati, Ohio. Mr. Deck was formerly vice-president of Wico Electric Co., West Springfield, Mass.

James C. Williams, previously with Pittsburgh Lectromelt Furnace Corp., Pittsburgh, is now a metallurgist with Thompson Products, Inc., Cleveland.

Moss V. Davis has joined the Anderson Brass Works, Inc., Birmingham, Ala., as chief metallurgist. He was formerly with Western Electric Co. in Winston-Salem, N.C.

Roger H. Lawton, former plant manager of the Rodney Hunt Machine Co., Orange, Mass., has accepted a position as general manager of Standard Machinery Co., Mystic, Conn.

Russell Stanford has resigned as chief of the metallurgy section, U. S. Atomic Energy Commission, Fernald, Ohio, to join the Nuclear Power Development Department of the Detroit Edison Co. He is assigned to Atomic Power Development Associates, Inc., Detroit, as chief of fuels separations section, with the responsibility of developing a suitable fuel reprocessing process for the proposed A.P.D.A. fast breeder reactor.

Personals . . .

Philip G. DeHuff has been transferred by Westinghouse Electric Corp. from the Aviation Gas Turbine Div., Kansas City, Mo., to the Atomic Power Div., Bettis Field, Pittsburgh. Formerly manager of production engines division, engineering department, Mr. DeHuff is now assistant to the manager of the pressurized water reactor project.

Albert H. Wilson has been transferred by Rolled Alloys, Inc., to Winchester, Mass., as sales representative. **James Skarda** succeeds him in the Cleveland-Pittsburgh sales office.

John Bergman is presently serving with the U. S. Army at Frankford Arsenal, Philadelphia, where he is assigned to the Scientific and Professional Personnel Program.

Frank J. Kearns, formerly vice-president in charge of engineering of the Bridgeport Brass Co., Bridgeport, Conn., has been appointed vice-president in charge of manufacturing, a newly created post. Mr. Kearns has been with Bridgeport Brass since 1935 when he started in the rolling mill. In 1942 he was named superintendent of the rolling mill at Indianapolis, Ind., and returned to Bridgeport in 1944 to direct the post-war planning of the company. In 1945 he became chief process engineer, in 1949 was appointed head of the engineering department, and in 1950 he was elected to the post he held until his recent promotion. Mr. Kearns is a graduate of the metallurgical engineering school of Lehigh University.

R. A. Pomfret has been promoted to chief of development and research, central technical department, of the Shipbuilding Division of Bethlehem Steel Co., Quincy, Mass. Mr. Pomfret is a graduate of the University of Alabama with a B.S. degree in metallurgical engineering. He joined the Bethlehem organization in 1935 as assistant materials engineer and later became materials engineer, which position he held prior to taking over his new duties. He succeeds **Paul Ffield**, who was recently transferred to Bethlehem, Pa., as technical adviser on the staff of the operating vice-president.


In Building it's...
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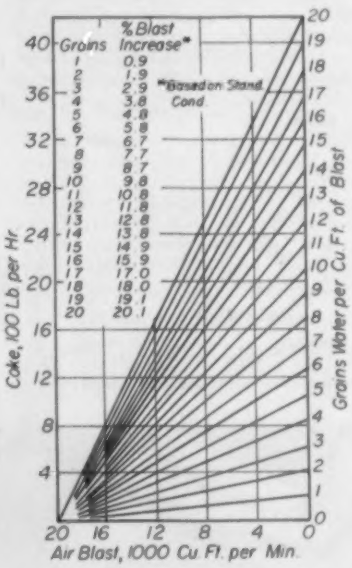
To manufacturers whose building products are competing for a place in the more than a million homes, farm buildings, schools, apartments, office and public buildings that are going up this year, Revere Aluminum offers attractive new opportunities.
It offers the ultimate user the advantage of strong, light-weight products that are high in serviceability and attractiveness and low in their need of upkeep. It offers the manufacturer almost unlimited scope in design plus the competitive feature of ready workability for low-cost and fast production.
Revere Aluminum is available in the forms of tube, extruded products, coiled and flat sheet, circles, blanks, awning stock, bus bar, forgings, Lockseam tube, rolled shapes, and foil. Revere Copper and Brass Incorporated, Founded by Paul Revere in 1801, 230 Park Avenue, New York 17, N. Y.
REVERE KNOWS ITS A-B-C's
ALUMINUM BRASS COPPER

Effect of Blast Humidity on Cast Iron Quality*

The moisture content of the cupola air blast has very definite effects on the quality of the cast iron melt. With all other conditions maintained constant, an increase in the moisture content of the air blast decreased metal temperature and carbon absorption from the coke, and increased oxidation of silicon and manganese from the metal charge. When carbon and silicon contents are decreased by a blast high in moisture, the chilling of the iron is increased sufficiently to change from gray iron to partially white iron in thin castings such as piston rings.

The accompanying chart, prepared by Battelle Memorial Institute,



Effect of Moisture Content of Blast on Coke Requirements

shows graphically the increase in coke required to compensate for moisture in the cupola blast. Control of the melting process by coke adjustment is difficult and unsatisfactory because changing coke requires changing air volume, and because moisture content of the air can vary so widely and rapidly that accurate compensation is almost impossible. A far better method of control is to dehumidify the air to a constant

(Continued on p. 148)

*Digest of "Holding Blast Humidity Constant", by Joseph L. Brooks, *American Foundryman*, Vol. 26, December 1954, p. 41-43.

Blast Humidity . . .

moisture content, then coke, air volume, and other factors can be held constant to insure a constant and predictable melting performance. Dehumidification was successfully accomplished with an ice machine at the Sparta Div. of the Muskegon Piston Ring Co. in 1927. Later, solid absorbents were used. Since 1940 a Kathabar system using lithium chloride as an air washer has been in successful operation. Cupola blast air is continuously dehumidified to 3 grains H_2O per cu. ft. of air at 75° F. The lithium chloride solution is regenerated continuously by spraying over steam coils.

The resulting uniform moisture content of the blast eliminates an important variable in cupola melting and gives more uniform composition and temperature of the molten metal. C. K. DONOHO

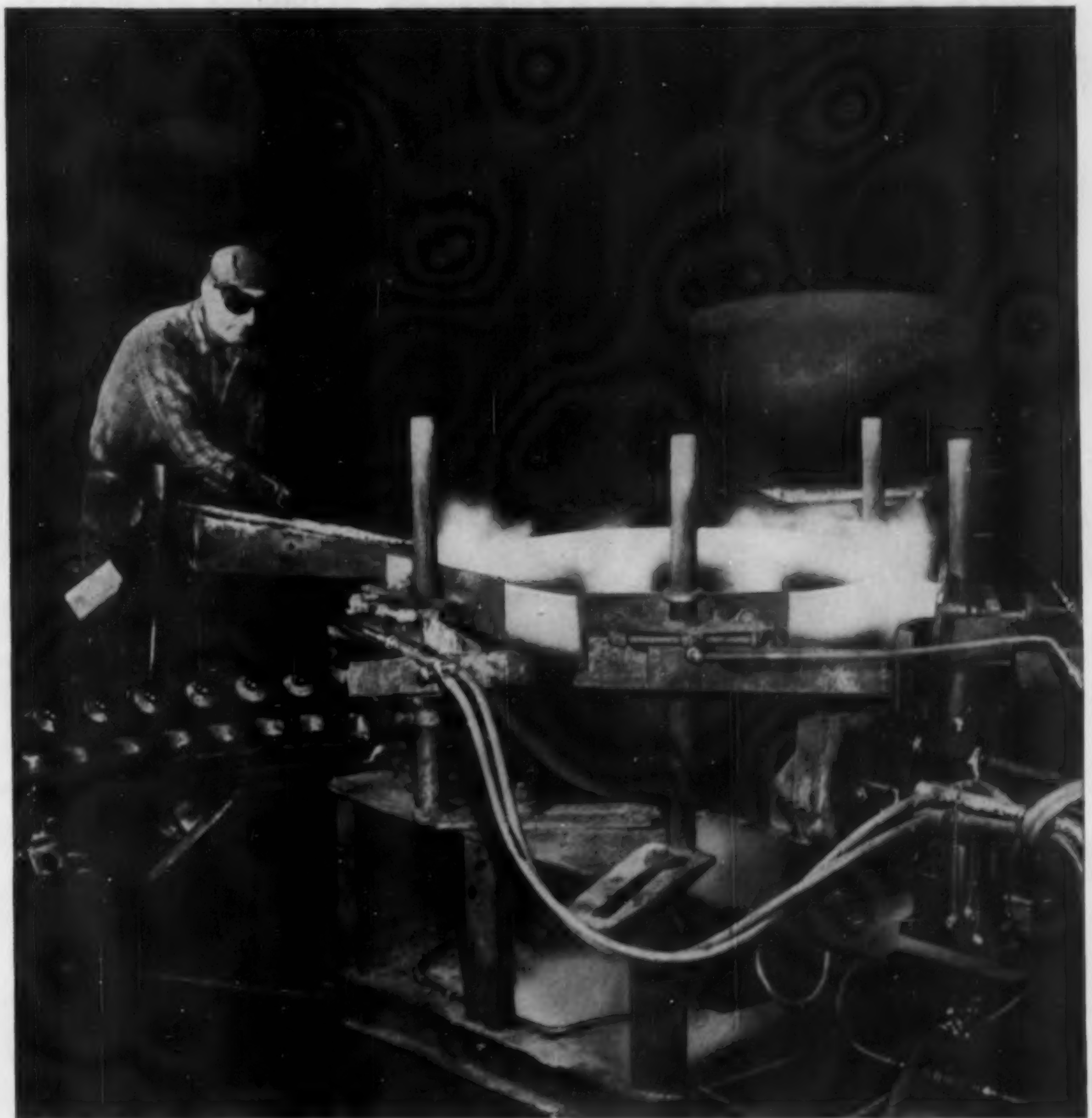
Effect of Cobalt on Diffusion of Carbon*

ACCORDING to the authors, there is need not only for data on the effect of cobalt on the diffusion of carbon in iron, but also for information on the carbide-forming tendency of cobalt. This article reports the results of experiments on the rate of decarburization of iron-carbon-cobalt alloys.

The alloys used in these experiments were prepared by melting Armco iron in a graphite crucible and had a constant carbon content of 4%, and cobalt contents of 0, 1, 3, 4, and 5%. Decarburization was carried out in pure hydrogen on sheets about 0.5 mm. (0.020 in.) thick prepared by liquid rolling, as previously described by Krishtal. Diffusion coefficients of carbon in austenite were calculated from the results of these tests and are shown in the diagram. The values for the cobalt-free alloy are in about the range to be expected on the basis of the work of Wells and Mehl,

(Continued on p. 150)

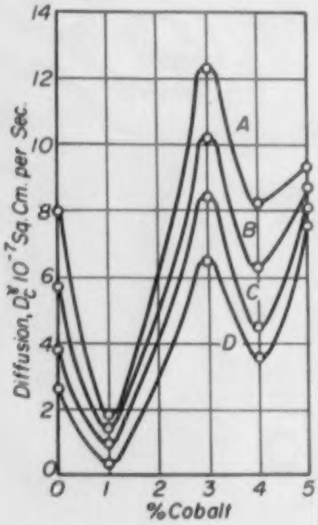
*Digest of "Influence of Cobalt on the Diffusion of Carbon in Iron-Carbon Alloys", by V. A. Yurkov and M. A. Krishtal, *Doklady Akademii Nauk SSSR.*, Vol. 92, 1953, p. 1171-1173.



Diffusion of Carbon . . .

indicating that the experimental method was suitable.

The oscillation with increasing cobalt content of the diffusion coefficient for carbon was explained as follows: Dekhtyar has attributed the effect of a third element on diffusion in a binary alloy to changes in the Fermi energy, but this reasoning would predict a monotonic change with increasing concentration. Another possible explanation might be one in terms of changes in the interatomic binding in the alloys. If such



Effect of Cobalt Content on the Diffusion Coefficient of Carbon in Fe-C-Co Alloys at Four Temperatures (A, B, C and D) Varying From 1740 to 1920° F.

changes occur, it should be possible to observe their effect also on other physical or physico-chemical properties. The property chosen for study was the initial difference in electrolytic potential in 0.01 molar H_2SO_4 solution between Armco iron and the alloys in question. The plot of potential versus cobalt content had exactly the same form as that shown above for diffusion coefficient.

Although there is at present no theory on which an explanation of these results can be based, it is possible that there are stable atomic groupings at cobalt contents of 1 and 4% that impede the diffusion of carbon. Also, it seems necessary to assume that the cobalt remains in the austenite rather than entering the carbide phase.

A. G. Guy

Bundy design increases production on accelerator rods—saves 45% on costs

At right is a typical example of how Bundy can operate to help you in your design needs. In this application, the solution to the problem of accelerator rod production was not only simplified design, but a remarkable cost savings of 45%!

Why not check with us in your own tubing design needs? When you call in a Bundy Engineer at the design stage of your product, you can be assured of successful results. As the leading manufacturer of small-diameter tubing, Bundy has developed an engineering staff of experts who can tackle and help solve your most difficult problems.

Find out about the high quality of Bundyweld Tubing. Remember, Bundyweld is the only tubing that is double-walled, yet stronger. It has high thermal conductivity, high bursting strength, is leakproof, and takes easily to any fabrication operation. Bundyweld is the safety standard of the refrigeration industry, *and is used in 95% of today's cars, in an average of 20 applications each.*

For further information, call, write, or wire us, today.

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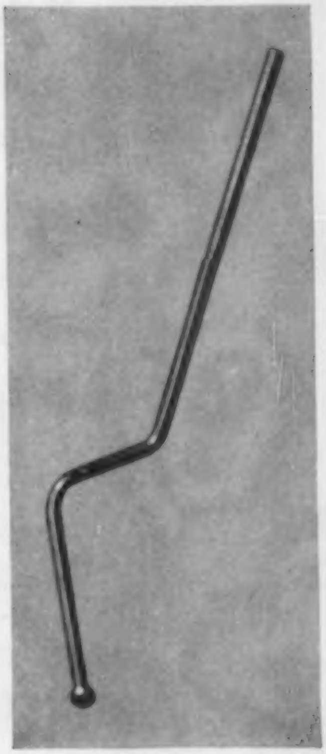
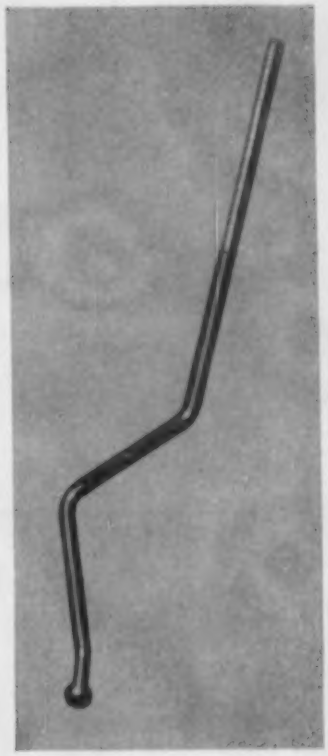


PROBLEM:

Building a light touch into an automobile accelerator used to be an expensive proposition. Rod linkage has to be rigid and precisely machined. For example, the solid steel rod shown above had to be forged into a ball on one end, machined and threaded on the other, and bent to a precise configuration on a press. These operations were very costly.



SOLUTION:

The simplified Bundy design started with a piece of 1/4" O.D. Bundyweld. A spherical end is formed by automatic press at a high production rate. The other end is swaged and roll threaded, and the rods are bent to specifications on hand fixtures. Result: accelerator rods were produced at 45% savings in cost, at a higher rate of production than the old way.

Bundyweld starts as a single strip of copper-coated steel. Then it's

. . . continuously rolled twice around laterally into a tube of uniform thickness, and passed

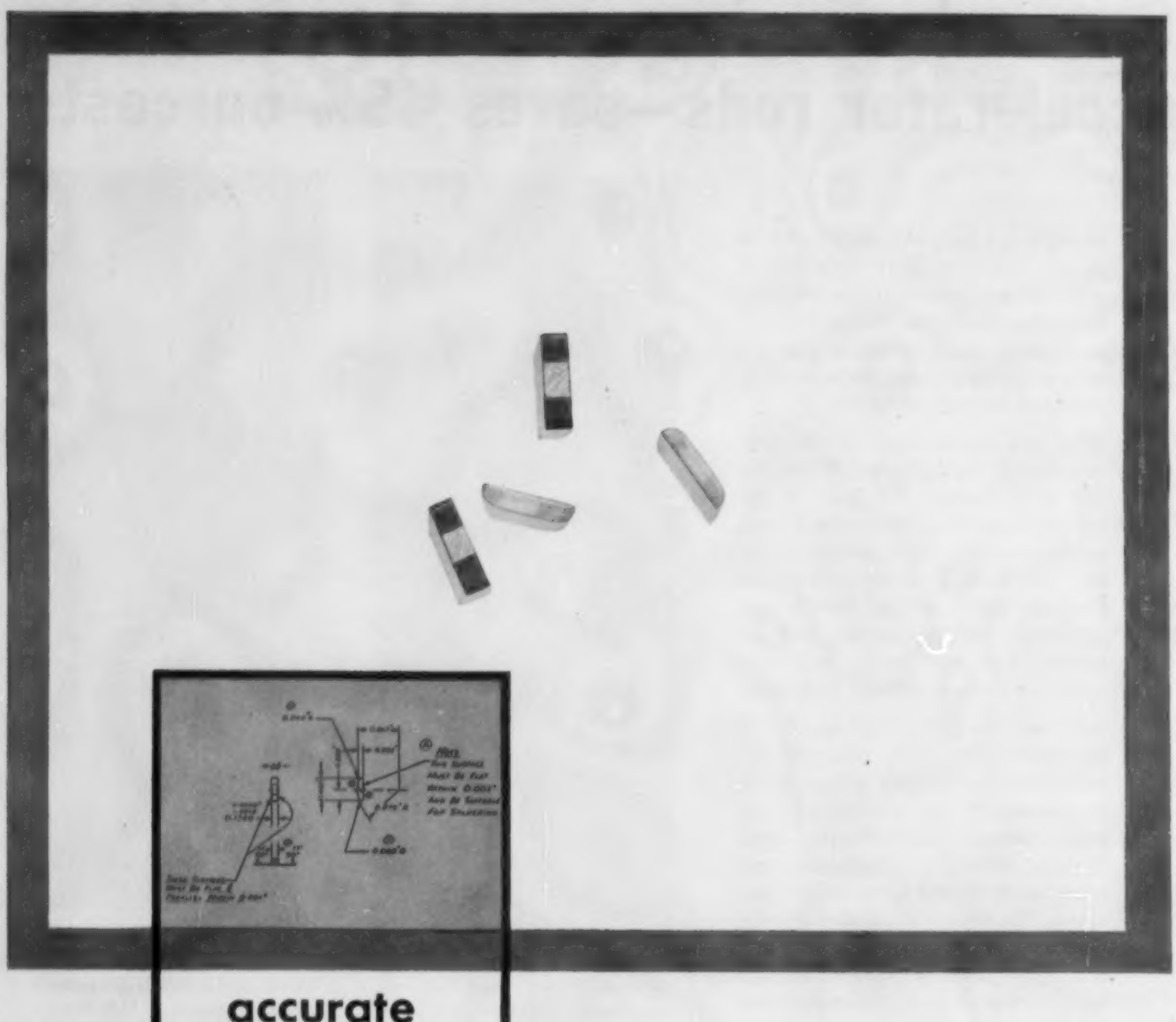
through a furnace. Copper coating fuses with steel. Result . . .

Bundyweld, double-walled and brazed through 360° of wall contact.

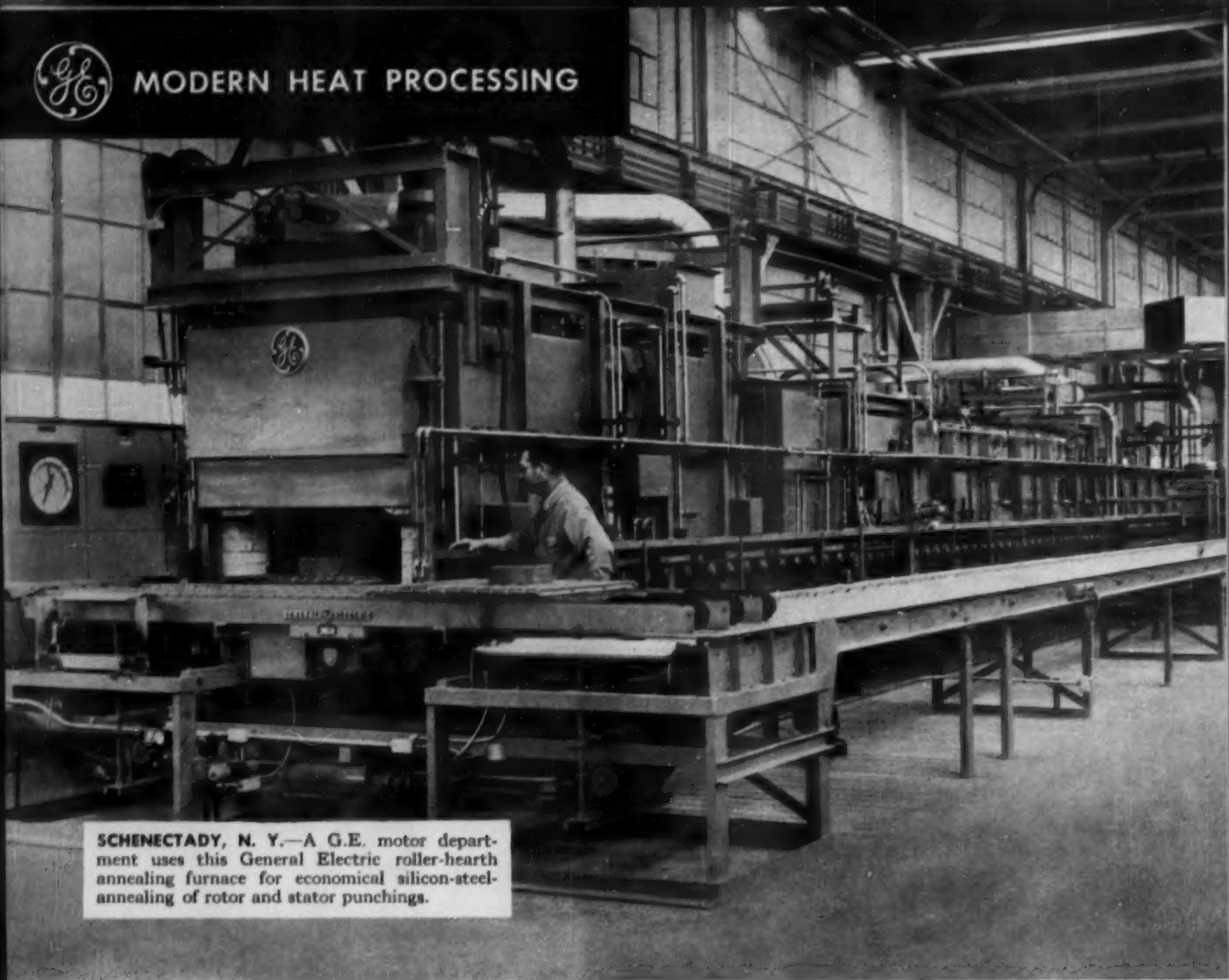
NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any leakage.

BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP



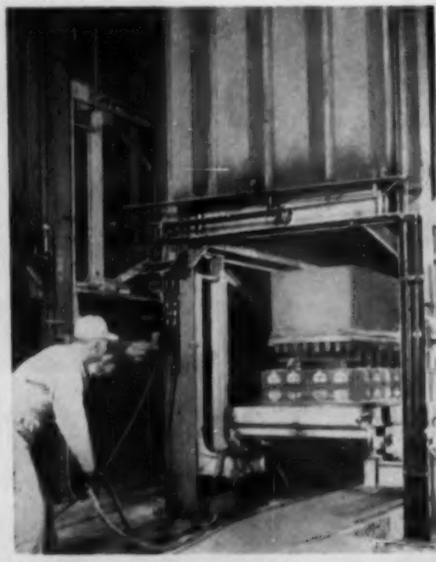
MODERN HEAT PROCESSING



SCHENECTADY, N. Y.—A G.E. motor department uses this General Electric roller-hearth annealing furnace for economical silicon-steel-annealing of rotor and stator punchings.

WIDE VARIETY OF G-E ANNEALING FURNACES NOW LETS YOU ANNEAL SILICON STEEL RIGHT IN YOUR OWN PLANT

Take a tip from General Electric, user of about 25% of the country's production of silicon steel—you can cut costs by annealing your own silicon steel. There's a General Electric silicon steel annealing furnace for nearly every type of annealing application—large or small. For example, the furnaces at right are located in different G.E. plants, each handling a different size silicon-steel-annealing job — *economically*.



G-E ELEVATOR FURNACE at Rome, Ga. plant is used for high temperature annealing of transformer cores—furnace fits in minimum space.

G-E BELL FURNACE, Waynesboro, Va. Low-production unit anneals machine parts at low cost.

Corrosion Problems in Hospital Practice*

SURGICAL equipment of all varieties is normally handled in atmospheres highly favorable to corrosion, by virtue of high moisture content and relatively high temperatures. Most cutting instruments, or "sharps", are cold rolled carbon steel containing about 1.3% C, hardened by heating to around 1375° F., quenching and tempering at 400 to 475° F. They are particularly susceptible to corrosion, and this, plus frequent damage to fine cutting edges through careless handling, causes understandable irritation among surgeons. Better knowledge of the mechanism of corrosion and preventive methods is needed.

A clean metal surface, once exposed to air, quickly develops an oxide film which builds up and progressively limits penetration of further oxygen until, for all practical purposes, the process stops. At this point, no change in appearance is observable, but in the presence of moisture a further change may occur as a result of gradual solution of metallic ions in the water, bringing about obvious corrosion. The exact mechanism of the latter action is not entirely clear, although an important factor is an insufficiency of oxygen.

Corrosion usually starts at distinct points rather than over an entire surface. These may be areas of damage to the oxide film and a rate of ionic solution of metal exceeding that of re-formation of the protective oxide. This is most likely to be found in crevices or cracks where oxygen replacement is slow, and also in parts of instruments more or less protected from the air, such as in the joints of scissors. A corrective is the addition of alkali which suppresses metal ionization and promotes formation of oxide film.

A number of solutions for storage of surgical instruments depend for their effectiveness upon added alkali. Alcohol, despite its unreliability as a sterilizing agent and potential risk of initiating corrosion by formation of oxidation products, has long been a favorite storage liquid. Its general

(Continued on page 158)

*Digest of "Corrosion Problems in Hospital Practice," by S. J. Hopkins, *Corrosion Technology* (England), Vol. 1, November 1954, p. 330 to 332.

Corrosion Problems . . .

use today, however, is declining.

In general, solutions with a pH above 7 and free from obviously reactive substances, are considered noncorrosive. Lysol, by virtue of its soap content, is satisfactory, as are such products as "liquor chloroxylenolis". However, these alkaline storage solutions are seldom used for hypodermic needles because they cannot be relied upon to penetrate the lumens. The choice in this instance is usually alcohol, either pure or with 5% liquor chloroxylenolis. Rusted needles stored in these solutions usually are traceable to accidental dilution with water.

Stainless steel is being used to an increasing extent in British hospitals, particularly for containers of various types. It is not generally favored for cutting instruments because of the difficulty of working the metal and the high hardening temperature. Cutting edges are not entirely satisfactory and the response to grinding, honing and stropping is less reliable than with carbon steel.

Hospital staffs do not usually appreciate that the term "stainless" is a relative, not absolute, designation. Instruments made from a 12% straight chromium steel, best described as rust resisting, have a degree of corrosion resistance closely connected with the heat treatment of the steel and final finish of the surface. Furthermore, if the instrument is stored for any length of time in contact with another metal, corrosion, once started, may be rapid.

The value of electroplating as an anticorrosive measure is well recognized. Most surgical instruments are plated with nickel and if this coating is damaged corrosion will develop in the usual way. Some nickel-plated instruments are given added protection by a thin deposit of rhodium which is extremely hard and durable, although apt to speed corrosion in the event of a break in the plate.

Influence of dust on corrosion is considerable, although it seldom receives much attention. Rusting of iron, even in a damp atmosphere, can be delayed appreciably if dust is absent. Lanolin is used extensively for the protection of steel articles, but it has little or no value if the film thickness is below a critical level corresponding to a weight of lanolin of about 1.5 mg per sq.in. One investigator has shown that this weight is equivalent to a thickness of about 2 microns and suggests that this critical thickness is in some way correlated with the particle size of atmospheric dust which may range from 0.25 to 2 microns.

Density of some dust particles is high and the slow penetration of such particles which may fall on a soft protective lanolin is quite likely. When this occurs the larger size particles conceivably may be in contact with both the underlying metal and the atmosphere, thus acting as focal points for the penetration of atmospheric moisture and initiating corrosion.

Silicone lubricants have been applied to surgical equipments such as scissors, forceps and the like as a protective coating. Ordinary lubricants are removed easily by sterilizing, but the silicone oils have surface adhesive properties of a considerably higher order. Lubricants based on silicone D.C. 200 have been found to prevent corrosion and to resist removal by sterilizing, as well as reducing the need for frequent oiling of the instruments to which they have been applied.

A. H. Allen

Invitation to Entrants . . . .

10th Metallographic Exhibit

Entries are invited in the 10th A.S.M. Metallographic Exhibit, to be held at the National Metal Exposition in Philadelphia the week of Oct. 17 through 21, 1955. Entries will be displayed to good advantage and awards will be given for the best micrographs as decided by a committee of judges.

Awards and Other Information

A committee of judges will be appointed by the Metal Congress management which will award a First Prize (a medal and blue ribbon) to the best in each classification. Honorable Mentions will also be awarded (with appropriate medals) to other photographs which, in the opinion of the judges, closely approach the winner in excellence. A Grand Prize, in the form of an engrossed certificate and a money award of $100, will also be awarded the exhibitor whose work is adjudged best in the show, and his exhibit shall become the property of the American Society for Metals for preservation and display in the Society's National headquarters in Cleveland.

All photographs may be retained by the Society for one year and placed in a traveling exhibit to the various Chapters. They will be returned to the owners in May 1956 if so desired.

Classification of Micros

BLACK AND WHITE PRINTS

1. Carbon and alloy steels
2. Stainless steels and heat resisting alloys
3. Iron, cast and wrought
4. Aluminum, magnesium, beryllium, titanium and their alloys
5. Copper, nickel, zinc, lead and their alloys
6. Metals and alloys not otherwise classified
7. Series showing transitions or changes during processing
8. Welds and other joining methods
9. Surface phenomena
10. Results by unconventional techniques (other than electron micrographs)
11. Slags, inclusions, refractories, cermets
12. Color micros (prints; no transparencies accepted)

Rules for Entrants

Work which has appeared in previous metallographic exhibits held by the American Society for Metals is unacceptable. Photographic prints shall be mounted on stiff cardboard; maximum dimensions should be limited to 15 by 22 in. Heavy, solid frames are not permissible because of difficulties in mounting the exhibit. Entries should carry a label on the face of the mount giving:

Classification of entry
Material, etchant, magnification
Any special information as desired

The name, company affiliation and postal address of the exhibitor should be placed on the BACK of the mount.

Transparencies will NOT be accepted.

Entrants living outside the U.S.A. should send their micrographs by first-class letter mail endorsed "Photo for Exhibition—May be opened for customs inspection." To be acceptable as first-class mail the package should measure no more than 35 x 45 cm. (14 x 18 in.)

Exhibits must be delivered before Oct. 10, 1955, either by prepaid express, registered parcel post or first-class letter mail, addressed to:

A.S.M. Metallographic Exhibit
National Metal Exposition
Convention Hall
Philadelphia 4, Pa.

37th National Metal Congress and Exposition

Philadelphia 4, Pa. October 17 to 21, 1955

Oxidation of Ni-Cr Alloys*

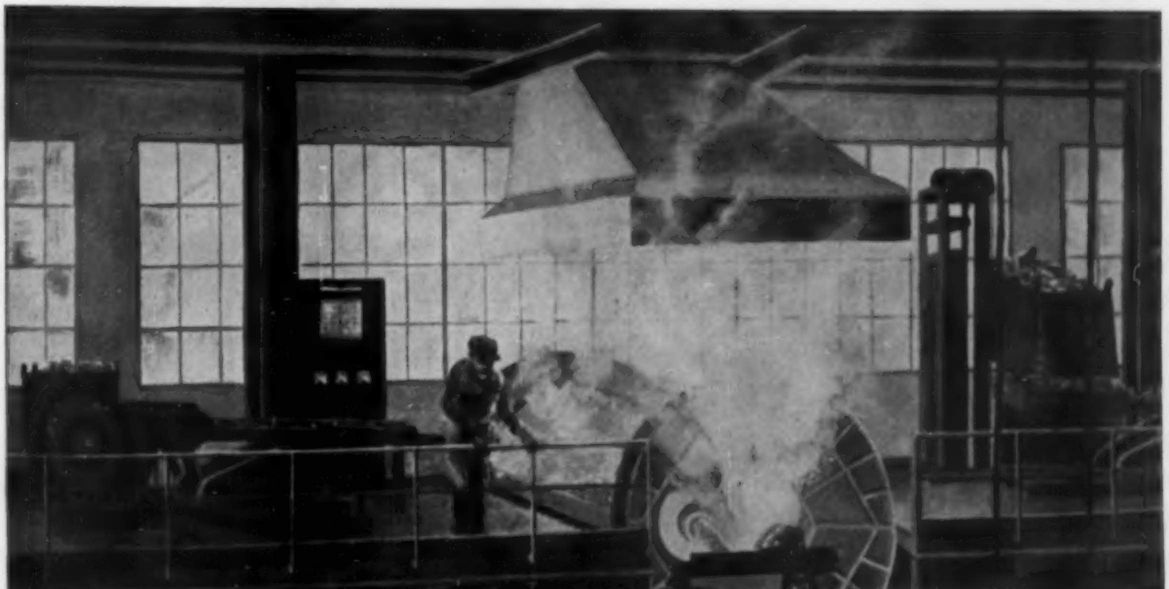
A LAYER of oxide of uniform thickness forms on a nickel-base chromium alloy when exposed to air at temperatures above 1830° F. This oxide layer is composed of two phases; nickel monoxide (NiO) and nickel chromate ($NiCr_2O_4$). When the oxidizing power of the atmosphere is reduced, selective oxidation of the more readily oxidized element occurs. In this case, chromium would be oxidized on the surface. In this investigation, the selective oxidation was observed on a 4 to 6% chromium-nickel alloy in a water vapor and hydrogen mixture of varying oxidizing power.

Because reproducibility of the experiment was largely dependent upon the surface condition of the alloy, a method of surface preparation was established. Small plates of specimens were mechanically polished, washed, electrolytically polished, and then heated in a pure, dry hydrogen atmosphere for several hours at 2190° F. Commercial hydrogen was completely freed of oxygen and was then saturated with water vapor. The water vapor and hydrogen mixture was regulated by adjusting the temperature in the saturator. The test specimen and the water vapor and the hydrogen atmosphere were brought together in a reaction chamber at various temperatures. A temperature range of 1470 to 2280° F. and a ratio of water vapor to hydrogen pressure of 6.5×10^{-5} to 5.9×10^{-3} were studied.

After treatment, the test specimens were examined microscopically and by electron diffraction. It was possible to observe the transition of the structure of the oxide as the temperature, partial pressure, or both were increased. The authors presented their data diagrammatically, which indicated the temperature range and the ratio of water to hydrogen pressure for primary nucleation of the oxide particles, nucleation and recrystallization, coalescence, evaporation of the oxide and striation of the metal, and the forma-

(Continued on p. 162)

*Digest of "The Selective Oxidation of Nickel-Chromium", by J. Moreau and J. Benard, *Journal of the Institute of Metals*, Vol. 83, November 1954, p. 87-93.



Skimming the pot prior to pouring into tiny 1 lb. capacity band-and-wedge molds.

BRASS MELTING THROUGH 150 YEARS

According to tradition and available records, founders of the Scovill Mfg. Co. of Waterbury, Conn. were first in the New World to cast brass bars commercially for subsequent cold rolling, at the old Abel Porter casting shop in Waterbury, Conn.

From this modest beginning has grown the huge Scovill Works employing thousands of employees and producing enormous quantities of cold-rolled brass. One of the initial steps in the process is the melting of brass in three of the largest and most powerful electric melting furnaces ever made, one of which is shown in the picture above.

In the early 1800's the man-hour rate of production with charcoal pit fires was from 5 to 10 lbs. In the early 1920's when AJAX INDUCTION FURNACES were installed, the man-hour rate was 800 lbs. Since 1949 when the latest type AJAX furnaces were installed man-hour production has increased five fold, and is now 4,000 lbs.

These modern 1000 KW AJAX Furnaces have a holding capacity of 20,000 lbs. with an hourly melting rate of 5 to $5\frac{1}{2}$ tons.

Photos at right show a unique demonstration staged by Scovill at the Hotel Statler in Hartford of America's first practical brass casting method. Here an operator in authentic brass caster's clothes of the period illustrated the casting of metal melted by the old bellows-blown pit fire used in the early 1800's. The tools were loaned by the Mattatuck Historical Society of Waterbury.

Pouring from pot into molds.

Opening molds after pouring metal into them.

AJAX ENGINEERING CORP., TRENTON 7, N.J.

AJAX

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INDUCTION MELTING FURNACE

AJAX ELECTRO METALLURGICAL CORP., and Associated Companies
AJAX ELECTROTHERMIC CORP., Ajax Northrup High Frequency Induction Furnaces
AJAX ELECTRIC CO., The Ajax Hultgren Electric Salt Bath Furnace
AJAX ELECTRIC FURNACE CORP., Ajax Wyatt Induction Furnaces for Melting

Oxidation . . .

tion of a continuous oxide layer.

The observations from these experiments permitted some general conclusions on the nature of primary nucleation, grain-boundary phenomena, and the formation and disappearance of surface relief effects. Under conditions of moderate reactivity, oxidation occurred at particular spots on the crystal face. At higher reactivity, the initial mechanism of the reaction continued but the oxide particles were larger. Chromium impoverishment of the metal occurred adjacent to a particle of chromium oxide. It seems probable that a new oxide particle will form at some distance from the first particle rather than the initial oxide grow sideward.

During the formation of the oxide, there were bands adjacent to some grain boundaries and twinning planes that resisted the formation of oxide particles. It was observed that these bands were more distinct and wider when there was a large difference in the number of oxide particles on the surfaces of two adjacent crystals. It was also observed that the oxide-free band was always on the crystal having the fewest oxide particles. It appeared that a crystal surface has a strong tendency for oxide nuclei to form and there is a lesser tendency in the marginal zones of the grain boundaries.

Under conditions of high temperature and pressures, surface relief effects were formed on the metal. The appearance of grain-boundary relief effects was believed to be related to selective oxidation. During selective oxidation and the formation of chromium oxides, chromium atoms were removed from the crystal lattice. With sufficiently high temperatures, these vacancies were filled by the migration of nickel. The metal surface of the new crystal lattice formed a microgeometric profile corresponding to its state of free energy. The surface reliefs disappeared when the metal was heated in the neutral or reducing atmosphere. The striated surfaces were covered with a chromium oxide film. When heated in hydrogen, the oxide film disappeared and the surface tension of the metal was increased. Therefore, the profile becomes unstable and the projecting edges tend

(Continued on p. 164)

Oxidation . . .

to become level because of migration of the atoms. This theory is consistent with observations of other investigators, but more study is required to determine the relative stability of the crystal planes.

R. E. LOCHEN

Stress-Rupture Strength of Thermenol*

THERMENOL, a nonstrategic iron-base alloy containing 16% aluminum, developed by the Naval Ordnance Laboratory, is an oxidation resistant alloy that may be suitable for use at elevated temperatures. This report describes a preliminary investigation conducted to determine its stress-rupture life at 1100 and 1200° F., room-temperature tensile strength, and bend ductility.

The material tested analyzed 16% Al, 3.3% Mo, balance iron. It was vacuum melted from high-purity components, cast into ingots, and hot rolled to size. The 0.020-in. sheet was heat treated at 1920° F. for 2 hr. and air cooled. The results of five stress-rupture tests at 1200° F., nine at 1100° F. and four tensile tests at room temperature were:

1. At 1200° F., Thermenol has a 100-hr. stress-rupture strength of 19,300 psi. This value is between the strength values for Types 310 and 321 stainless steels (19,000 and 26,000 psi., respectively). It is inferior to both of these stainless steels for times beyond 100 hr.

2. At 1100° F., it has stress-rupture life roughly equivalent to that of the Types 310 and 321 stainless, the stress-rupture strength for 100 hr. being 35,500 psi. and the strength for 1000 hr. 23,000 psi.

3. The average tensile strength at room temperature is 62,050 psi. with 3% elongation (average) in a ¾-in gage length, compared with 92,000 psi. with 47% elongation

(Continued on p. 166)

*Digest of "Preliminary Investigation of Stress-Rupture and Tensile Strength of Thermenol, an Iron-Aluminum Alloy", by Charles A. Gyorgak, *Research Memorandum N.A.C.A.-M-E 54 F 10*, August 1954, published by National Advisory Committee for Aeronautics, Washington 25, D.C.

Thermenol . . .

(2-in. gage length) for 310 and 85,000 psi. with 58% elongation (2-in. gage length) for 321 stainless.

4. A quasi-quantitative ductility test, which measured angle of bend in degrees, did not specifically indicate bend anisotropy between longitudinal and transverse directions. Ductilities in the longitudinal and transverse directions at room temperature were about equal, ranging from 34 to 56% and 34 to 48%, respectively. J. J. Becker

Editor's Note: C. W. Lufcy (head of magnetics division of the Naval Ordnance Laboratory, White Oaks, Md., and one of the discoverers of the alloy) was quoted in *Science News Letter* for March 6, 1954, as saying that "It also seems to offer great promise as a heating-element material for coffee makers, electric ranges, toasters and commercial annealing and heat treating furnaces. This is because its electrical resistivity is 50% higher than that of the more expensive nickel-chromium alloys." The metal is 20 to 25% lighter than stainless steel.

Ferritic Nodular Iron Versus Steel*

By means of a comparison of heat treated ferritic ductile (nodular) iron with a 0.24% C steel (Ref. 1) it is emphasized that the generally usable ductility of the two is practically equivalent, and that nodular iron exhibits no yield point (yield stress in Britain) but has a smooth stress-strain curve like austenitic alloys. The chief difference in ductility is the extension after maximum load, the steel exhibiting pronounced necking and about twice as much reduction in area as the iron.

This additional elongation after maximum load occurs is considered an asset of the low-carbon steels only in cases of accidental gross over-strain or deformation with tearing, as may happen with an explosive force. In those applications where there is likelihood of brittle failure, it is stated that both nodular

(Continued on p. 168)

*Digest of (1) "Some Observations on the Ductility of Ferritic Nodular Iron", by G. N. J. Gilbert, *Journal of Research and Development*, British Cast Iron Research Assoc., Vol. 5, December 1954, p. 470-472; (2) "The Impact Properties of Ferritic Ductile Iron", by R. W. Kraft, Symposium on Effect of Temperature on the Brittle Behavior of Metals With Particular Reference to Low Temperatures, American Society for Testing Materials, 1954.

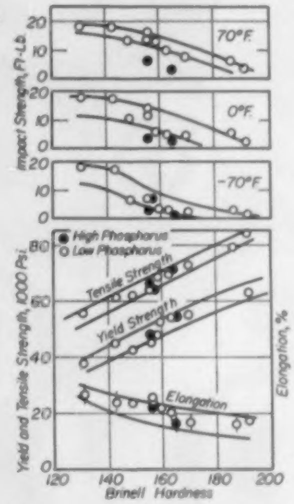

Fig. 1 – Hardness-Tensile and Hardness-Impact Relationships in Ferritic Ductile Iron

Tensile Properties of Mild Steel and Ferritic Ductile Iron

	Gage Length	Yield, Psi.*	Ultimate, Psi.	Elongation		Reduction in Area
				At Max. Load	Total	
Steel†	2 in.	44100	72600	22%	39%	62%
Steel†	4	46100	70800	21	31	63
Iron‡	2	34700	58700	20	29	30
Iron‡	4	33200	57400	21	26	28

*The values for steel are the yield point indicated by a drop in load. Those for iron are the British 0.05% (permanent set) proof stress.

†0.24 C, 0.07 Si, 0.76 Mn, 0.021 S, 0.020 P.

‡3.27 C (total), 1.90 Si, 0.27 Mn, 0.033 S, 0.085 P, 0.63 Ni, 0.070 Mg, 0.014 Ce.


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Nodular Iron . . .

irons and steels should be judged on a basis of transition temperatures.

According to Reference 2, ferritic ductile irons do not have abrupt transition temperatures, but exhibit a gradual change from ductile (dark) to brittle (bright or shiny) fracture. Using a graphic multiple correlation technique on impact data from A.S.T.M. "Y" specimens (round and notched), it was demonstrated that both silicon and phosphorus raise transition temperatures, brittle fractures occurring at 70° F. for 0.06% P with 2.65% Si or about 3.0% Si with 0.036% P. At 0° F., 0.02% P with 2.65% Si is required to avoid brittle fracture. Nickel had no effect on impact values.

Industrial ferritic irons may require minimum tensile properties of 60,000 psi. ultimate, 45,000 psi. yield strength (0.2% offset) and 10% elongation. The pearlitic ductile irons are stronger and less ductile. There is a vague correlation of elongation with high impact strength (Fig. 1), but this is not practically useful. A combination of the tensile specification with composition control is indicated where insurance of ductile fracture is required. Since the ferrite hardening effects of both silicon and phosphorus may be reduced by composition control intended to increase impact strength, and thereby make the specified strength levels difficult to obtain, the hardening of ferrite by nickel to compensate provides a means of meeting tensile requirements with a high

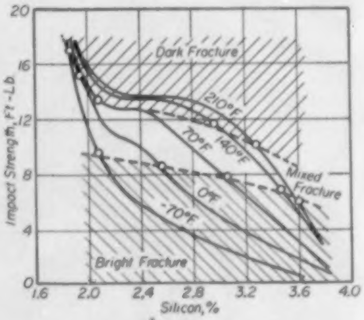

Fig. 2 – Effect of Silicon Content on Impact Strength and Type of Fracture at Various Temperatures

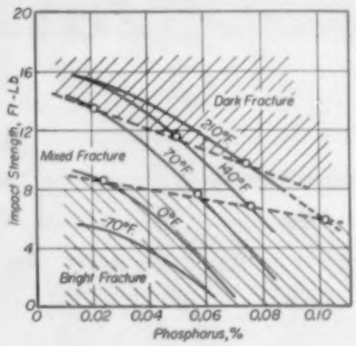

Fig. 3 – Effect of Phosphorus on Impact Strength at Various Temperatures

level of impact resistance. Such alloying should be adjusted to avoid the occurrence of pearlite, which reduces ductility and also reduces impact strength below the level expected from the same composition when fully ferritic.

The impact values and the effects of silicon and phosphorus are summarized in Fig. 2 and 3.

Howard S. Avery

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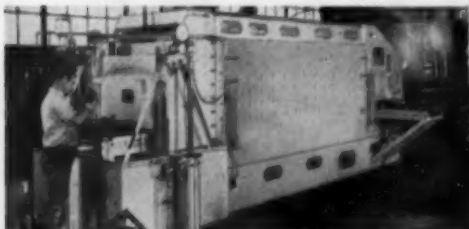

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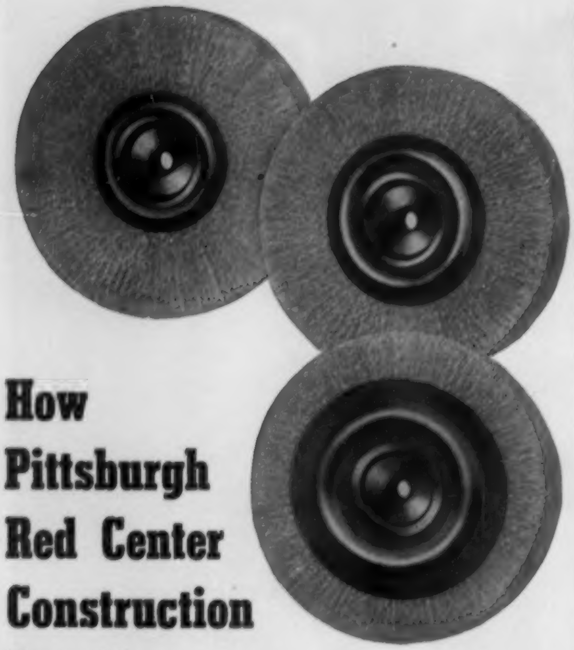

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